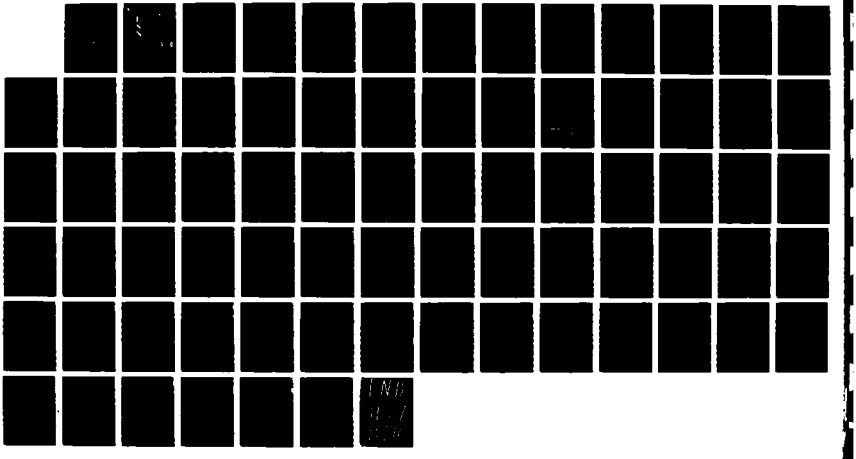

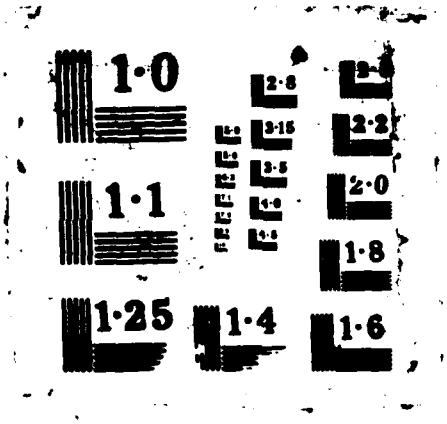
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U.S. Office of Naval Research, London
Vol 41 No. 10 October 1987

European Science Notes

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

ADA185091

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 41-10	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION US Office of Naval Research Branch Office, London 6b. OFFICE SYMBOL (*If applicable*) ONRL	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (*City, State, and ZIP Code*) Box 39 FPO, NY 09510	7b. ADDRESS (*City, State, and ZIP Code*)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (*If applicable*)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (*City, State, and ZIP Code*)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO / WORK UNIT ACCESSION NO.
11. TITLE (*Include Security Classification*) European Science Notes--(UNCLASSIFIED)	
12. PERSONAL AUTHOR(S) C.J. Fox, Editor	
13a. TYPE OF REPORT Monthly 13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (*Year, Month, Day*) Oct 1987 15. PAGE COUNT 67
16. SUPPLEMENTARY NOTATION	

17 COSATI CODES			18 SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)

European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. Qualified US scientists travelling in Europe may also be invited to write an ESN article.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL C.J. Fox	22b TELEPHONE (*Include Area Code*) (44-1) 409-4340 22c OFFICE SYMBOL 310

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

U.S. Government Printing Office: 1986—607-044

European Science Notes

US Office of Naval Research, London

Commanding Officer ..... CAPT Terry J. McCloskey, USN
Scientific Director ..... James E. Andrews
Editor ..... C.J. Fox

October 1987
Volume 41
Number 10

Partial contents:

Behavioral Sciences

Issues that emerged from this annual meeting of the National Security Industrial Association Conference in Luxemburg in May 1987 are discussed. The author concludes that the use of artificial intelligence (AI) machines holds enormous promise for training, but that AI should not be oversold nor should its development be delayed.

Biological Sciences

Topics under which reviews of selected papers given at this conference, held in May 1987 in Belgium, are: chemiluminescence enzyme immunoassays, fiber-optic sensors in biomedical sciences, use of luminescence techniques in high-pressure liquid chromatography, and the application to drugs of luminescence assays.

Computer Sciences

The various groups and activities of the university's Computer Science Division are profiled. The division is judged to be very strong in comparison with US equivalents, producing a large number of publications in new areas of investigation, but the computer facilities available to it are somewhat limited and could hamper further development.

Electronics

The work of Cambridge University's Department of Materials Sciences and Metallurgy is reviewed; in particular, the experiments with sputter-deposited YBaCuO thin films.

NAVSO P-3624

Material Sciences

Imperial College's work in solid oxide fuel cell research and in metal organic chemical vapor deposition are discussed. The current research activities are in some of the most important areas in electronic ceramics, and, the author believes, should keep Imperial College in the forefront of the technology for the foreseeable future.

Studies presented at this all-French conference on the fiber matrix interface covered the use of acoustic emission, forced vibrations, fragmentation, and microindenting methods. Surface treatments of the fibers were by carbon coatings, nitrogen plasma, and various chemical agents. Presentations were also given on studies of the microstructure surface energies and critical shear stress of the interface.

Mechanics

Discussion of the papers presented in this symposium, held in Göttingen, West Germany, in May 1987, is organized under the following topics: laminar/turbulent transition in boundary layers; coherent structures in the modeling of turbulent boundary layers, wakes, and jets; experimental facilities and techniques; and calculation methods for turbulent flows.

Belgium's Von Karman Institute is incorporated as an international research center, and functions also as an integral part of Belgium's higher eductional structure. The academic and research programs are reviewed--in particular, those of the environmental and applied fluid dynamics, aeronautics and aerospace, turbomachinery, and computational fluid dynamics departments.

Ocean Sciences

This is a general report on the 1987 MIZEX field program. It provides a background, beginning with the summer field program in 1983, describes the various area's and activities of the 1987 program--which concerned the Fram Strait region between Svalbard and Greenland--and gives a summary of the BAJA MIZEX portion of the program.

Papers presented at the session on oceanography at the meeting of the European Association of Remote Sensing Laboratories, held in May 1987 in the Netherlands, are discussed. Topics covered are wind and waves, ocean topographiy, ocean color, sea-surface temperature, and ice.

Physics

This article reviews research in many areas of optics, optoelectronics, laser development, laser applications (primarily spectroscopy), optical bistability, surface physics relevant to optoelectronic and microelectronic devices, broadband and coherent optical communication, optical signal processing, and integrated optics, persued at several departments at the Technical University of Berlin and at the Heinrich Hertz Institute (Berlin).

This report is a profile of an organization which is both a private engineering school and a research institute. Activities in theoretical and experimental solid-state physics, acoustics, microelectronics, informatics, and robotics and control are reviewed.

Space Sciences

This colloquium of the International Astronautical Union (IAU) was held in June 1987. Selected papers are reviewed under the topics of general methods, perturbative methods, computer algebra, quantitative methods, statistical methods, Kirkwood gaps, reference frames, rotational motion, stellar systems, and galaxies.

News and Notes

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European Science Notes is a Class I Periodical prepared and distributed by the Office of Naval Research, London, in accordance with NAVSO P-35.

Behavioral Sciences

REPORT ON THE NSIA INTERNATIONAL CONFERENCE ON MILITARY PERSONNEL AND TRAINING, WITH SPECIAL EMPHASIS ON COMPUTER ADAPTIVE TESTING AND TRAINING

by William Crano. Dr. Crano is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Texas A&M University, where he is a Professor of Psychology.

The annual meeting of the National Security Industrial Association's (NSIA) International Conference on Military Personnel and Training was held in the City of Luxembourg from 5 through 7 May 1987. This was the sixth annual meeting of the NSIA, the first in Europe. The conference drew representatives from the military, scientific, and industrial sectors, all of them focused on issues of military manpower, personnel, and training.

The mix of skills and needs represented in this conference (and in the NSIA itself) is remarkable. In the space of 3 days, training technologists became much more informed about military needs, the military about the recent advances in--and limitations on--testing and training technology, and the scientists about the difficulties that face them today in the design and validation of training systems and the even greater challenges that they will face in the future. Copies of many of the talks presented at this conference are available in a book of proceedings, which can be obtained from NSIA National Headquarters, 1015 Fifteenth Street, NW, Suite 901, Washington, DC 20005.

The keynote speaker for the conference was General Wolfgang Altenburg (West Germany [FRG]), whose work as a strategist for NATO was immediately apparent by the wide-ranging knowledge he demonstrated in his thoughtful and incisive opening remarks. Better than any keynote speaker I have heard, Altenburg laid before the participants the central issues with which they were to grapple over the course of the conference. To put one issue most starkly, let's consider some simple demographics. Given current projections, it is apparent that before long, the military manpower needs of the FRG will exceed its annual (male) birthrate. Even if all the boys of the entire birth cohort for a given year were conscripted, their numbers still would prove insufficient for perceived needs. This is not an isolated problem. Almost all the developed western countries will sooner or later confront the same issue. The problem is obvious, the solution less so. In light of current shifts toward reduction of nuclear weapons, budget cutbacks, and the corresponding need for an increase of military manpower, the shortfall is bound to be exacerbated over time, rather than ameliorated.

While most applaud the mutual reduction of East-West nuclear forces, the issues as seen from the perspective of the German officer were clearly more complex than many may have realized. In his view, since the end of World War II, stability in Europe had been maintained by nuclear weapons. Although no one wanted to use such weapons, because of simple numeric inferiority Western strategists did not think that the NATO forces could sustain themselves in a conventional European war for more than 6 or 7 days. If some accommodation had not been reached at that point, the option was to "go nuke." Put another way, nuclear weapons were used to deter not only the other side's use of their nuclear weapons, but also their use of their superior conventional forces. If the nuclear response option were to be removed through arms limitation treaties, Altenburg argued, then the current and historic imbalance of conventional forces between the NATO and Warsaw pact countries would become untenable. Issues of this sort keep strategists awake at night.

One solution to the problem of declining population lies in the substitution of manpower by machines, coupled with the training of men (and women) in such a way that their effectiveness is commensurately greater than that of opposing forces. If Army A's soldiers are five times more capable than Army B's, then the fact that Army B has twice the forces does not mean much. Of course, the substitution of man by machine calls for machine operators of greater intelligence, since ever more sophisticated machinery will be required if the substitution is to have the intended effect. It is to this crucial, but relatively straightforward issue, that the work of the conference was devoted. In the paragraphs that follow, I will attempt to provide a flavor of some of the work discussed in this meeting. The proceedings hold more detailed descriptions, along with the addresses of the speakers, should follow-up communication be desired.

Computerized Adaptive Testing

One means that may be used to help offset the anticipated manpower shortfall

consists of a testing approach that more rapidly and more accurately places recruits into the highest military specialization for which they qualify. With the ever-increasing technological demands of new weapons systems, it is important to match recruits with specializations that take maximal advantage of their cognitive and physiological capacities. In an interesting presentation, Friedrich Steege and Wolfgang Wildgrube (German Federal Ministry of Defense, Bonn) discussed ways in which the German Federal Armed Forces were attempting to meet this challenge. They appear to be placing considerable emphasis on the method of the computerized adaptive testing (CAT).

CAT is a method, or form, of assessment which may be employed in the evaluation of almost any cognitive attribute, be it intelligence, personality, or knowledge. In CAT, questions are dynamically tailored to the respondent, with each succeeding item dependent upon the correctness of the respondent's prior answer. The dynamics of the approach are simple, and obviously quite different from standard paper and pencil methods. In CAT, if the respondent answers one question correctly, the estimate of his ability is updated by the computer, and a more difficult item posed subsequently. If the candidate fails to answer this succeeding question correctly, the estimate is again adjusted, an easier item presented, and so on. Eventually, a very accurate picture of a particular aspect of the respondent's cognitive or personological system can be developed. Thus, in a test of knowledge about maintenance of a jet engine, a CAT-based test would pose questions about the inner workings of the engine only after the respondent had demonstrated that he possessed sufficient knowledge to open the engine compartment. In a CAT-based test of arithmetic knowledge, items dealing with multiplication and division would not be posed before the candidate had demonstrated competence in addition and subtraction.

Put in this way, CAT appears to be little more than a more advanced way of delivering assessment questions. But it is more than this because the medium through which the assessment takes place can result in greater validity of classification; that is, CAT promises more differentiated, accurate, and sensitive data than that which is available through more standard methods of assessment. In addition, CAT is administratively more flexible. Assessment can be undertaken at any time, individually, without the need to bring together large groups for standardized testing. Finally, the procedure can be more humane. If an individual cannot answer easy questions, it is not reasonable to bombard him with a series of even more difficult items. Such an experience can prove humiliating, and the consequent negative attitude toward the testing situation can generalize to its sponsor. Thus, CAT at its best can even be viewed as a positive public relations device.

Technical problems remain to be solved in the use of CAT. Obviously, the approaches of classical test theory to determine the reliability and validity of instruments cannot be employed in a straightforward manner in CAT settings, since all respondents answer a different series of questions. However, alternatives, including item response theory, have been employed with some success (cf. Hambleton, 1983).

The hardware necessary for a CAT facility is quite modest. In the German Federal Armed Forces, two pilot CAT facilities have been constructed, at Munich and Hildesheim (near Hannover), to field test the system in the conduct of medical examinations and psychological testing. In the German approach, the CAT facility consists of a host IBM-AT with a 20-MB hard disk, a backup AT, and a local area network for up to 15 terminals. Each terminal would have a hard disk, video screen, headphones for voice instructions, and a special keyboard, modified to suit the requirements of the test.

It remains to be seen if CAT will produce all that it promises, but an educated guess is that it will. With hardware costs continually dropping, CAT appears to be a fine way to maximize the quality of selection, while at the same time minimizing administration costs. The major roadblocks to more widespread CAT implementation are not hardware, but have to do primarily with issues of test validity and software development. Both of these issues are tractable, given sufficient time and resources. Indeed, in the German Federal Armed Forces, CAT is already being used in the selection of officer candidates, the placement of draftees, and the selection of specialists.

CATs, CATTs, and ICATs

CATT. It is only a small step from computerized adaptive testing (CAT) to computerized adaptive testing *and training* (CATT). If a program can be structured to pinpoint the specific strengths and weaknesses of a respondent in a given cognitive realm, then why not modify the program so that it can teach a specific skill, and monitor the learner to determine when the requisite knowledge has been absorbed? The reasonableness of this notion was so compelling that CATT

is now a feature of military training in the US, the FRG, and other countries as well.

CATT is subject to the same reliability and validity problems as the more basic CAT techniques, but it holds the promise of accelerated training programs, at greatly reduced costs. With CATT, we can train any number of students to a preset standard without regard to instructor costs; after the initial developmental costs have been absorbed, only hardware and program maintenance costs remain. The savings promised by CATT systems are astonishing--if the quality of training they provide equals that of hands-on training, and if such systems can be developed within reasonable time frames. At this conference, Herbert Aschenbrenner (FRG Ministry of Defense) discussed the psychological aspects of the interdependence of selection technology and training technology, and found no fundamental incompatibility between their requirements.

ICAT. A considerably more ambitious concept involves *intelligent* computer assisted training (ICAT), or intelligent tutoring systems, as they also have been called. The advances in artificial intelligence (AI) research are the basis for this approach, whose promise is at least an order of magnitude greater than that of the more basic CATT approaches. It is not mere hyperbole to suggest that AI will someday revolutionize the fundamental process of instruction, that it will change the ways we teach and the ways we learn.

Applied in a military training context, the problems and promise of tutoring systems based on AI approaches are readily apparent. Put most simply, with ICAT, the student is presented information, and then tested on his understanding. Misconceptions are identified and analyzed automatically, and appropriate remedial instructional information is provided to offset the errors. Only after appropriate learning is demonstrated does the program pass to the next phase of instruction. The intelligent tutor not only presents information, it analyzes when and *where the student has gone wrong*, then chooses the most optimal strategy to correct the misunderstanding, tests its hunch, and then--and only then--if the strategy has proved successful, goes on to the next phase of instruction. If not, it recycles through the instructional strategy stage again, choosing yet another approach that optimizes understanding.

With instructional problems of even moderate complexity, the task of constructing intelligent tutors is enormous. Indeed, Suppes (1984) and Ohlsson (1986) both have observed that ICAT's have yet to be developed for situations involving practical training problems of even moderate complexity. However, as Park and Seidel (US Army Research Institute, Alexandria, Virginia) suggested in their presentation, the principles necessary to develop such systems are already understood. They proposed that in the development of an ICAT system, four subsystems (or "modules," to use their words) were needed:

- The expertise module would consist of the domain of knowledge that the intelligent tutor needs to impart to the student. Equally importantly, the module also would contain information about the procedures available to use the knowledge most effectively to solve problems. This "procedural knowledge" is derived from the insights and behaviors of experts in the particular content area under study.
- The student module is concerned with the learner--his or her current knowledge, misconceptions, learning history, and possibly individual difference characteristics (intelligence, personality structure, etc.).
- The tutorial module determines when, the manner, and the rate at which different instructional materials and information are presented the student. This module may contain many different instructional approaches, and, in addition, the rule system to determine when one or another is employed.
- The interface module handles the important task of communication between student and program. It develops the instructional presentations, and translates the student's actions into a language that can be understood by the program.

A schematic representation of an ICAT system based on these four modules, their subcomponents, and their functional interdependencies (drawn from Park and Seidel's presentation) is outlined in Figure 1.

Of course, the schematic represents the ideal. The size and complexity of such a system would tax even the most sophisticated of computers. However, with increasing speed and capacity of currently available hardware, it seems likely that the necessary processing equipment will be available soon, if it is not already in place. The central problems arise in the software systems, and the knowledge bases the systems will attempt to represent. Consider, for example, a brief listing of some preliminary issues that must be faced by the

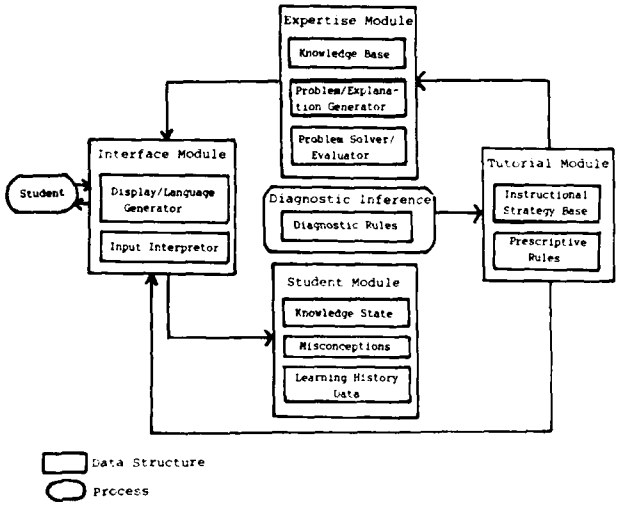

Figure 1. A schematic representation of an ICAT system (adapted from Park and Seidel).

developers of intelligent tutoring systems:

- The expertise module contains information regarding the domain of knowledge that the program seeks to impart to the student, and expert strategies (i.e., procedural knowledge) to maximize the utilization of the knowledge. Assuming that it is possible to specify a domain of knowledge--and in some restricted circumstances, this might not prove impossible--the development of strategies represents a major obstacle. The strategies will be used both to generate problems and provide explanations for the student. However, the translation of expert knowledge to useful training principles is notoriously difficult. We have studied the procedural knowledge of chess experts for decades, yet a truly effective training system based on this knowledge of procedure still eludes us. The difficulties involved in extracting the expert knowledge from an ace fighter pilot and transforming this procedural information to useful instructional material is no less a challenge.
- The student module contains information about the current knowledge state of the learner, along with individual difference information that could help the tutorial module decide upon the most effective training tactic. Theoretically, this makes great sense. However, we still know relatively little about the complicated nature of "aptitude-treatment" interactions--i.e., the ways in which different instructional methods (treatments) might differentially influence students of different aptitudes. It seems very unlikely to me that a solution (or sets of solutions) to the aptitude-treatment interaction puzzle which will prove of utility to ICAT designers will surface in the foreseeable future.
- Based on the student's performance, the tutorial module is designed to decide upon the most appropriate teaching strategy. However, the way in which information is best conveyed is still a controversial subject. How are the strategies of information presentation to be decided upon?
- Finally, let's consider the interface module. This subsystem is designed to facilitate communication between learner and program. On the surface, this appears the least problematic area, depending more upon programer skill than knowledge of cognitive or social psychology. But if we were to adopt more fully the precepts of AI, then this module, too, would adapt itself to the student, fostering different student-program interfaces as a function of the skills and preferred communication style of the learner. Given our dearth of knowledge of communication strategies most appropriate for specific types of individuals, such a changing interface seems most unlikely.

What, then, are we to conclude from this? Is it reasonable even to consider the application of AI technology to instructional problems? Do such attempts stand a chance? In my opinion, such questions cannot be answered with a simple yes or no. If one is looking for an immediate payoff, then AI-based technology will probably provide little comfort except for the most simple problems where the domain of knowledge is extremely circumscribed, the possible strategies of knowledge utilization few, and the interaction of strategy with individual differences in the learner minimal. There are problems of this sort, they can be exceptionally important (as shown by BBN Laboratory's L.D. Massey, who presented his work at the conference), and AI-based training procedures have already been developed for them. However, problems of this type are not common, and there is some question in situations such as these whether AI offers much beyond traditional instructional approaches.

If one has the resources to take a longer perspective, then it is obvious

that AI-based systems *must* be pursued. If nothing else, these approaches highlight the knowledge that we already possess and, more importantly, that which we must create. AI has set and will continue to set the research agenda for some of our best and brightest cognitive psychologists, and this can only be a good thing. It is clear, however, that more disciplines must become more involved in the problems that have surfaced as a result of work in AI. We know, for example, that cognitive psychologists have much to say about strategies of learning; but developmental psychologists, too, might prove very useful in specifying the manner in which training strategies might be sequenced to facilitate learning of a new knowledge domain. Social psychologists and communications specialists might prove extremely useful in decisions regarding the most appropriate way to present information to a student, once the particular type of information (or strategy) had been decided. A huge investment of money and time, much greater than that evident today, is needed if the promise of truly useful and general intelligent tutoring systems is to be realized. But the promise is so grand, by comparison, that it dwarfs the investment.

Concluding Reflections

Three general "types" of speakers were present in the conference--military men, designers (of training equipment, simulators, selection devices, etc.), and researchers. The military speakers dealt primarily with strategic issues, with personnel and training needs, and with the outcomes of applications of training strategies and devices. They were quite impressive. Their discussions of current strategic issues were first rate, and their challenge to the research and design community to develop means of improving their capabilities was straightforward and reasonable. The designers, too, were impressive. Although they often appeared clearly to have an eye on future sales, their work was presented carefully, and the utility of their products continually stressed. It was when the researchers presented their work that most of the trouble started. It was clear that some of the researchers purposely "watered down" their presentations, in the belief that their audience did not have the requisite training to follow the scientific marginalia of their work. This was a drastic mistake, because in doing so, their presentations left unanswered some fundamental questions of the validity of their findings, and of the transferability of their work to the field.

A simple example should suffice here. In one presentation, a researcher discussed his experience with a new simulation device. Cost savings over training with the "real" weapons system were discussed, pass-fail rate presented and contrasted with that involving hands-on training, etc. Nowhere, however, did the speaker talk about the relative quality of the simulation-trained versus the traditionally trained student. Objections from the military to presentations of this type were predictable. "How do we know it works?" That was fair question, and one, unfortunately, that many speakers simply could not answer in a straightforward manner. Indeed, in one of the discussions, a speaker from the Norwegian Air Force declared that he did not believe that flight simulators were of any value in teaching pilots. His challenge, "You cannot teach a person to fly on a simulator" went largely unanswered--despite the breath-taking investment in such devices evident in many of the NATO countries. Of course, it is obvious that flight simulators do have value, and this point could have--indeed, should have--been made forcefully. The fact that it was not suggests that the researcher did not have available in memory the comparative data that must have been produced at some point, and this, in turn, suggests that he might have lost track of some very fundamental principles of the logic of scientific proof.

From the scientific community, the objections to researchers' presentations devoid of validity and generalizability information was equally challenging, and suggests that we have not completely forgotten our recent educational history. One of the most eloquent critiques of the scientific work was given by Jesse Orlansky, of the Institute for Defense Analysis. His objection was that the research ers were so awash in technology that it, rather than good ideas, was driving training. Obviously, the progression should be opposite to that currently evident--training must dictate the technology.

To me the situation today is comparable to that witnessed in the field of elementary education in the 1950's and early 1960's, where new educational technologies often were adopted wholesale, without any empirical information suggesting their effectiveness relative to the technology already in place. Often, such fads did no damage, but neither did they make for improvement. The net effect of their adoption, thus, was the expenditure of lots of money, a certain degree of dislocation of teachers and students, and no change in amount or rate of learning--it was all for nothing.

Orlansky appeared to be suggesting that this scenario was too often replayed in military training. His questions--"Why use a computer to replace paper? Where's your imagination?"--were far more than rhetorical, but nonetheless went unanswered.

Obviously, much greater emphasis on the validity and generalizability of simulation training must characterize presentations of research of this nature. At the AI end of the spectrum, where such information sometimes is really not available, we should not expect to find a smokescreen obscuring this fact. It is obvious that training techniques based on AI technology hold enormous promise. Equally clear is that premature and overblown promises of immediate paybacks of AI technology to today's training can, perhaps will, produce disillusionment in both the scientific and the research-funding communities. It is easy to promise more of AI than it *now* can deliver. To delay the inevitable development of AI teaching devices because of an inability to deliver on unrealistic promises would be a needless disaster. It has happened before. Let us hope it does not happen again.

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7/22/87

Biological Sciences

QUANTITATIVE LUMINESCENCE SPECTROMETRY IN THE BIOMEDICAL SCIENCES

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1988 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

The Second International Symposium on Quantitative Luminescence Spectrometry in Biomedical Sciences was held at the Faculty of Pharmaceutical Sciences, State University of Ghent, Belgium, from 11 through 14 May 1987. Eleven European countries were represented among the 180 participants as well as the UK, US, Israel, Japan, Canada, Egypt, and East Germany. Seventy-three percent of the attendees were from academic institutions and the balance represented industrial organizations.

The conference consisted of long (1 hour) and short (20 minute) oral presentations as well as 37 posters. A small exhibition of equipment and reagents related to the conference topics including demonstrations of instruments and assays was also included.

The topics presented at the conference included:

- Chemiluminescence enzyme immunoassays
- Chemiluminescence: applications to drug analysis
- Immobilized and solid-state reagent systems for luminol chemiluminescence
- Luminescent probes of protein dynamics
- Use of luminescence techniques for sensitive and selective determinations in high-pressure liquid chromatography (HPLC)
- Fiber optic sensors in biomedical sciences
- Fluorochrome-labeled gene probes to study gene expression.

Since a large amount of information was presented it is only possible to present a summary of selected topics in this short report. However, within the next 6 to 8 months the proceedings will be published in a special issue of the journal, *Analytica Chimica Acta*.

Chemiluminescence Enzyme Immunoassays

The quantitation of hormones with chemiluminesence immunoassay was discussed by J. De Boever (Department of Gynecology, University Hospital, University of Ghent, Belgium). Since the first description of a chemiluminescence immunoassay (CIA) for a steroid hormone in 1979, a large number of important analytes, including hormones, can now be measured with CIA. The most frequently used chemiluminescent compounds are luminol, isoluminol, and acridinium salts. CIA's have been described for peptide hormones such as thyroid stimulating hormone (TSH), insulin, and many others, and

also for thyroxine, and triiodothryronine as well as for steroid hormones such as cortisol, estradiol, testosterone, etc. CIA's for the steroid hormones usually involve an extraction procedure, but some are direct assays--i.e., without extraction of the steroid from, for example, serum. During the past year several companies have started marketing CIA kits. In most instances, a simple luminometer/biocounter can be used. However, for some assays, more sophisticated and costly measuring devices are required. According to De Boever, the commercialization of CIA, although not established as yet, will be expanding because the method is sensitive and, more importantly, is a nonisotopic immunoassay which can therefore be used without special safety precautions in clinical laboratories.

A new method for the detection of Hepatitis B surface antigen in serum was described by G. De Schrijver (Department of Internal Medicine, State University of Ghent, Belgium). The method uses a system based upon the very high affinity between avidin and biotin and a fluoroimmunoassay. In the procedure, antibodies are covalently bound to a glass fiber disk which traps the antigen. The disks are then treated with monoclonal antibodies (Mabs) of high specificity, species-specific anti-IgG biotin-linked streptavidin, and biotinylated beta galactosidase. The final incubation is performed with 4-methyllumbelliferyl-β-D-galactopyranoside as a substrate. The fluorescence signal was measured with the US Dade Diagnostic System, called "Stratus," which, although it could not handle the whole procedure itself, was very suitable for this purpose (according to De Schrijver) because of its high sensitivity and the technique of reading dynamical fluorescence rates.

A large number of serum samples were compared with the radioimmunoassy method of Abbott Diagnostics (Austra II) with no significant difference between the two methods.

A report on the development of a chemiluminescence immunoassay (CLIA) for progesterone in plasma incorporating acridinium ester-labeled antigen was presented by S.A. Miller (Tenovus Institute for Cancer Research, University College of Wales, Cardiff, UK). Solid-phase antiserum was prepared by coupling a monoclonal progesterone antibody raised against a progesterone-11-hemisuccinate/bovine serum albumin conjugated to cyanogen bromide-activated cellulose. The chemiluminescent label was on 11-progesteryl-2-carboxymethyltyramine-4-(10-methyl) acridinium-9-carboxylate conjugate. The CLIA procedure is simple. Samples of plasma (100 µl) were extracted with petroleum ether and the organic extract dried and reconstituted in assay buffer (300 µl). Aliquots of extract (100 µl) were incubated with label (100 µl) and solid-phase antibody (200 µl) for 2 hours at 37°C. Following centrifugation, the chemiluminescence was determined using a Berthold LB950 Automated Luminometer. The assay had a minimum level of sensitivity of 3 picogram/assay tube, and the assay compared very well with a radioimmunoassay in routine use. Thus, Miller and coworkers have shown that the progesterone-acridinium conjugate can be used in a competitive immunoassay as an alternative label to an isotopic label.

A chemiluminescence immunoassay of oxazepam (5-phenyl-1,3-dihydro-3-hydroxy-7-chloro-2H-1,4-benzodiazepin-2-one) was described by G. Zomer (National Institute of Public Health and Environmental Hygiene, Bilthoven, the Netherlands). Antiserum against oxazepam was raised against oxazepam-3-hemisuccinate-bovine serum albumin. As the tracer, the chemiluminogenic aminobutyl-(N-ethyl)-isoluminol conjugate of oxazepam-3-hemisuccinate was used. The assay was fast and highly sensitive and thus Zomer thinks it will be of importance in medical practice--pediatrics in particular--where single tablet ingestions of tranquilizers can give effects compatible with drug overdose but at low concentrations in urine.

A method for the measurement of estriol in saliva by CLIA was reported by J. De Boever (Department of Gynecology, University Hospital, University of Ghent). Chemical determination of estrogens in urine and, more recently, radioimmunoassay of estriol in blood have often been used for assessing fetoplacental function. Serum estriol concentrations, however, are characterized by substantial subhourly variations that may complicate clinical evaluation of results and may necessitate repeated sampling and assay, according to Zomer. Some of these problems can be overcome by measuring estriol in saliva. This body fluid can easily be collected and its estriol levels reflect those of the free estriol fraction in blood.

Thus, Zomer and coworkers developed a simple and fast nonisotopic immunoassay for salivary estriol. The assay uses a monoclonal antibody bound to the wells of microtitration plates and estriol labeled with the chemiluminescent marker molecule, isoluminol (E3-APEI). Incubation time is 10 minutes at room temperature. Chemiluminescence is measured using the microperoxide-catalyzed oxidation of isoluminol with hydrogen peroxide. The assay was specific, and detection level was 4 picogram estriol/well. Zomer reported that by using this CLIA, up to 40 saliva

samples can be analyzed and results calculated within 3 hours.

In another report, Zomer discussed his studies to determine optimal labeling of proteins with acridinium esters. Such experiments are important since proteins (especially Mabs) labeled with acridinium esters are used in immunochemiluminometric assays and such labeling is still not a routine method. Zomer described the effects of different conditions on the labeling of a model protein, human immunoglobulin (hIgG), with acridinium ester. The acridinium label that was used in this study contained an active N-hydroxysuccinimyl ester. The effects of pH, reaction time, temperature, and label/protein ratio on the protein labeling were investigated. It was found that the effects of reaction temperature (4, 20, and 37°C) on the labeling were minimal. The reaction time (5, 15, and 30 min) had only a moderate effect. The increase of label/protein ratio resulted in an almost proportionally higher label incorporation. The optimal pH for the labeling buffer was found to be pH 8; at higher pH, the label decomposed, while at lower pH less conjugation took place.

Fiber-Optic Sensors in Biomedical Sciences

A discussion of fiber-optic sensors as well as some of the research carried out in this area was presented by O. Wolfbeis (Institute of Organic Chemistry, Karl Franzens University, Graz, Austria). Optical fibers can be used for remotely sensing chemical and physical parameters. According to Wolfbeis, the usual approach is to provide the fiber end with a suitable indicator chemical or a material that responds to the parameter of interest. In contact with the sample, the intensity of reflected, scattered, or reemitted light is the analytical signal. Aside from several advantages of optical sensors over electrochemical ones--for instance, the lack of need for reference cells and the ease of miniaturization--the use of fibers, according to Wolfbeis, can be advantageous when the samples to be studied are inaccessible, as in the case of *in vivo* experiments. Fiber-optic sensors have been developed for temperature, oxygen, pH, carbon dioxide, and electrolyte. Apart from these parameters, which also may be sensed by other techniques, optical sensors have been developed that are based on quite new principles and which can make them useful for sensing glucose, enzyme activities, anesthetics, and antigen-antibody interactions.

Wolfbeis and his group have developed an optical sensor for hydrogen peroxide (HP) based on the finding that HP is able to penetrate polymer membranes. The sensing principle is fairly simple: an oxygen-sensitive indicator in aqueous solution, along with the enzyme catalase, is entrapped in a polymer membrane. When in contact with the membrane, HP diffuses through the polymer and is decomposed by the enzyme in the aqueous phase, thereby producing water and molecular oxygen, which quenches the fluorescence of the indicator. The amount of oxygen produced can easily be related to the HP concentration, according to Wolfbeis. Detection limits are in the range of 0.1 mM.

Wolfbeis said that the advantage of the optical sensor system over the electrochemical HP sensor--based on the same enzymatic decomposition reaction--is that the enzyme is separated from the sample solution with its varying composition and this can give rise to a decrease in enzymatic activity with time. In the sensor developed by Wolfbeis and coworkers, the enzyme is entrapped in a sterile environment and has no contact with the sample. Moreover, catalysts other than catalase (such as transition metal ions or platinum) can be used. It should be noted that the determination of HP plays an important role in analytical biosciences because all oxidases produce HP when oxidizing a substrate. A sensor for HP is therefore capable of quantifying both enzyme activities and substrate concentrations by measuring the amount of HP formed in the enzymatic reaction.

Wolfbeis and his group are also working on an optosensor for alcohol. They found that when a polymer membrane containing alcohol oxides is placed in the aqueous phase, an optical sensor for alcohol is obtained because alcohol can diffuse through the polymer into the aqueous phase, where it is oxidized and HP is produced. Again, no sensitive enzymes are exposed to the hostile sample condition. Wolfbeis and coworkers are also developing methods for the determination of glucose and other substrates.

Wolfbeis and his very productive group have also constructed an oxygen fiber sensor that is based on the measurement of the decay time fluorescence as a function of oxygen pressure. A long-lived dye (lifetime of about 650 ns) is periodically excited at a rate of 455 kHz, using a blue LED as a light source. Detection of the phase shift between excitation light and fluorescence, followed by averaging the signal, provides an amplitude-dependent relation between lifetime and oxygen pressure.

When compared to existing oxygen fiber sensors, the new one, according to Wolfbeis, has a few decisive advantages:

- 1-point calibration
- Low signal drift due to leaching and bleaching because the decay time is independent of dye concentration
- Excellent long-term stability because of an internal reference system
- No drift due to light source intensity and photodetector fluctuations.

Wolfbeis considers the new sensor type to present a considerable improvement over existing optical sensors. So far, practically all optical oxygen sensors have relied on the measurement of reduction in fluorescence intensity of a dye when it is quenched by molecular (triplet) oxygen.

Use of Luminescence Techniques in High-Pressure Liquid Chromatography (HPLC)

In the past decade, HPLC has gained widespread acceptance. Still, the sensitivity and selectivity of detection in HPLC often do not meet the requirements of modern trace-level determinations in biomedical and environmental samples. Among the currently employed detection principles, luminescence and, especially, its best known and most widely applied representative, fluorescence, appears to offer a high potential to achieve (sub)-parts per billion (ppb) detection limits in complex matrices. This latter statement was made by U.A.Th. Brinkman (Department of Analytical Chemistry, Free University, Amsterdam, the Netherlands), who discussed the use of luminescence techniques in HPLC. According to Brinkman, since the range of compounds displaying strong native fluorescence is relatively small, derivitization plays an important part in HPLC with fluorescence detection. Initially, precolumn derivitization (or labeling) was the preferred technique. Today, on-line post-column labeling is used frequently, and topics such as type of reaction, reactor design, and compatibility of HPLC and postcolumn reactor conditions must be taken into account.

Brinkman also mentioned the area of photochemical reactions. UV-visible irradiation converts the non- or weakly fluorescing analyte of interest into a highly fluorescent product (or products), which considerably enhances the sensitivity and selectivity of detection. The number of applications is fairly restricted; the method, however, is highly attractive because of its simplicity.

Brinkman mentioned that laser excitation sources are essential to apply fluorescence detection in miniaturized HPLC. The laser beams are highly collimated so that illuminated volumes as small as 10 nanoliters are readily attainable. Detector design is crucial because scattered light and "blank" luminescence limit the sensitivity. Up till now, continuous lasers have mainly been applied. A recent approach to reduce scatter and to enhance selectivity utilized two-photon excitation, which involves lasers with high peak power.

Brinkman also stated that in recent years, the analytical potential of room-temperature phosphorescence in homogeneous fluid and micellar solutions has repeatedly been demonstrated. This technique, which is complementary to fluorescence, extends the applicability range of luminescence detection in HPLC.

The limiting factor in the ultimate detectability of fluorescence is the background light that reaches the photomultiplier. Under proper conditions, elimination of the light source can, therefore, have a dramatic impact on detection sensitivity. One way to achieve this goal, according to Brinkman, is via chemical excitation or chemiluminescence. Although extensively utilized for batch analyses, on-line chemiluminescence methods of detection for HPLC are relatively new techniques. Brinkman emphasized that flow-cell and detector construction, pH and solvent selection, optimization of fluorophore type, and elucidation of the reaction mechanism are among the aspects that still require refinement and further experimental work.

Quantitation by chemiluminescence of marker enzymes for cholinergic neurons using HPLC separation of enzyme-monoclonal-antibody complexes was presented by E.J. Menzel (Institute of Immunology and First Department of Surgery, University of Vienna, Austria). Quantitation of cholinacetyltransferase (ChAT), a specific marker enzyme for cholinergic neurons, can be used to differentiate between motor nerves and sensory nerves. ChAT may be detected *in situ* using monoclonal antibodies (Mabs). In nerve extracts ChAT activity is determined by radiochemical techniques. Both assays are time consuming and of limited practical value in nerve transplantation surgery. Thus, Menzel and his group developed a rapid luminescent assay for ChAT activity which takes only 10 minutes to complete, including the extraction procedure. A constant amount of choline is in the presence of excess acetyl enzyme A and the nerve extract to be measured. The residual choline is then determined via choline oxidase. According to Menzel, the assay is sensitive and compares well with conventional methods. To eliminate interference by acetylcholinesterase (AChE), another marker enzyme of motor nerves and acting antagonistically to ChAT, nerve extracts were incubated with excess monoclonal-ChAT antibody, followed by HPLC

gel filtration on a Bio-Sil TSK 250 column. Since the antibody was noninactivating, ChAT activity could be measured in the immune-complex-containing fractions. Complete separation of the two marker enzyme activities was obtained. High-molecular-weight forms of AChE could be separated from ChAT by HPLC without addition of anti-ChAT antibodies. Thus, it is possible to quantitate both marker enzymes simultaneously by chemiluminescent assays. Menzel thinks that this procedure should be of great practical impact for nerve transplantation surgery.

Fluorochrome-Labeled Gene Probes

Investigation of gene expression by tracing the amount of messenger RNA (mRNA) transcribed from a gene has become increasingly important, especially regarding oncogene activation. K. Pachmann (Medical Clinic of the Technical University of Munich and the Institute of Immunology, Munich, West Germany) has developed methods for directly labeling gene probes with fluorochrome for tracing specific cellular mRNA in individual cells by *in situ* hybridization. The advantage of direct labeling procedures is the direct correlation between fluorescence intensity and the amount of gene probe bound per cell. Thus, it is possible to calculate the amount of specific mRNA accessible to the fluorochrome-labeled probe in individual cells.

Luminescence Assays: Application to Drugs

The fluorimetric determination of procaine in pharmaceutical preparations was reported by F.G. Sanchez (Department of Analytical Chemistry, Faculty of Sciences, University of Malaga, Spain). Procaine is an amino ester used as a local anesthetic. Due to its wide medical applications, several methods for the quantitative determination of this compound and its salts in pharmaceutical preparations are available. The present work was carried out by Sanchez and coworkers to elucidate the luminescence behavior of procaine when modifying the environment, both by changing the solvent used or by using surfactants or β-cyclodextrin in order to improve sensitivity of the fluorometric assay. These investigators carried out a detailed study of the effect that the change in polarity and dielectric constant of the environment causes in the fluorescence behavior of procaine included in β-cyclodextrin (β-CDx). It was found that N,N,-dimethylformamide helps procaine to be included in the micellar media (β-CDx) with a better fit. A linear dynamic range was established between 10 to 680 ng/ml with a detection limit of 2.5 ng/ml. The selectivity of the method was proved with synthetic mixtures containing other pharmaceutical substances (neomicine sulphate, amoxyciline, papaverine, etc.). The applicability of the method was carried out with several pharmaceutical preparations containing procaine with an average recovery of 108 percent.

The application of computer-aided luminescence spectroscopy to the determination of drugs and their degradation products was discussed by J.P. McCormick (School of Pharmaceutical Chemistry, University of Bradford, UK). With the advent of computer-aided luminescence spectroscopy it is now possible to determine fluorescent drugs and their major degradation products without resorting to chromatography. By the application of a number of deconvolution algorithms including derivative and variable-angled synchronous scanning methods, resolution of the often overlapping broadband spectra can be achieved, according to McCormick. When applying these deconvolution routines it is necessary to maximize discrimination between the available data sets. This can be achieved by generating the total luminescence data in the form of an emission-excitation matrix (EEM). One method for exploiting the difference between sets of known spectral data from overlapping systems is the method of least squares deconvolution. This can be applied directly or after transforming the spectra to the derivative domain, using zero-order and second-derivative spectra. McCormick and his group examined the selectivity of the least squares method in studies on two-component purine systems as well as carrying out preliminary studies on the possibility of application to a larger number of components produced during pharmaceutical degradation studies.

Conclusion

The studies presented at this symposium on quantitative luminescence spectrometry in biomedical sciences showed that this method is being used in many types of experiments in the biomedical sciences. The method is very sensitive and gives results fairly quickly. Improvements are continually being made in enchancing the sensitivity of the technique and in extending the range of application.

7/25/87

Computer Sciences

CONTROL THEORY AT THE NATIONAL TECHNICAL UNIVERSITY IN GREECE

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Electrical Engineering Department of the National Technical University of Greece has an enrollment of approximately 250 students. There are three divisions; Power, Electronics and Communications, and Computer Science. Research in the controls area is conducted in the Computer Science Division, which has a student enrollment of about 125. This division is directed by Professor Spyros G. Tzafestas, who was my host for the visit. Tzafestas received his Ph.D. from the Imperial College, London in 1969. Shortly thereafter, in 1972, he accepted the first chair in Greece to be devoted to control theory.

The department consists of over 20 professional people (professors and lecturers) with eight people listed as assistants (master's degree). As far as I could tell all the department members are Greek, but almost all of them have their doctorates from the US or UK from universities such as Stanford, Princeton, Columbia, and the University of California at Berkeley, and, in the UK, Salford, and Manchester. There are 44 candidates for the doctoral degree in the division and this organization would be considered a strong department anywhere in America.

Instructional Program

The instructional program follows the German pattern with a 5-year program in which the last 3 years consist of specialization in a given discipline. The fifth semester has courses in semiconductor, signal systems, programing languages, and logical design and includes two laboratory courses on computers and electronics. There is a good selection of courses in the advanced semesters (e.g., 15 in the 8th semester) which include digital imaging processing, compilers, pattern recognition, design of microprocessors, advanced controls, etc.

Research Program

The research effort is divided into 13 groups, described below, with each group involving one or more professors, research assistants, and doctoral candidates. Exterior publications are invariably in English and appear in journals such as the *IEEE Transactions in Automatic Control*, and the *International Journal of Control and Automatica*. I will note the professors in each group as a point of contact should there be any further US interest. Some of the professors are associated with more than one group.

Identification and Control of Systems. This group is under the direction of Professor N. Paraskevopoulis, who has two doctoral students and a number assistants. His work has involved eigenvalue sensitivity and assignment techniques with an average of six to eight papers published a year. Paraskevopoulis has also done quite a bit of work on the analysis of singular systems and on the use of orthogonal functions in control theory. Some recent work has concerned model reduction of large-scale systems and state and parameter identification of nonlinear systems using block-pulse function.

Computer Networks. Professor E.N. Protonotarios, Associate Professors E.D. Sykas, G.I. Stassinopoulis, and F.N. Afrati and seven doctoral students are involved in computer network research. Protonotarios' research is concerned with multiple access protocols and capacity assignment problems. Some more recent work has been with automatic request for repeat (ARQ) protocols. Stassinopoulos has reported work on congestion control in single destination and on fenchel duality and smoothness of solution of the routing problem. Afrati has worked on hybrid retransmission protocols for the data link layer, and Sykas on adaptive mixed multiple-access protocols. This group is particularly active in international symposia giving nine conference presentations in a recent year.

Image Processing-Computer Vision-Integrated Circuit Design. Associate Professor D. Anastassiou, one doctoral student and three research assistants work on image processing. Anastassiou has published articles on gray-scale image coding for freeze-frame videoconferencing. He has a US patent on nonlinear filtering for smoothing gray-scale images (1985). He has also been concerned with a video conference system based on a small computer (Series/1) with IBM associates. He has several publications in the *IBM Technical Disclosure Bulletin*.

Tools Methods and Architecture of Fifth Generation Systems. Professor G. Papakonstantinou and Associate Professor

E. Skordalakis along with seven doctoral students are working on fifth-generation systems. Papakonstantinou is concerned with knowledge representation and syntactical constructions. The work is directed at fault diagnostics and reliability. Most recently he has reported on attribute grammars as a diagnostic tool and error recovery using attribute grammars. Skordalakis' work has had a medical orientation in that he has been interpreting electroencephalgraph (EEG) waveforms. He has prepared a review on syntactic EEG processing which will appear in the journal, *Pattern Recognition*, and one of his recent papers is on primitive pattern selection and extraction in EEG waveforms. A recent doctoral work in this group was on an adaptable pipeline architecture with fault tolerance capabilities.

Intelligent Systems--Robotics and Control. The intelligent systems group is directed by Tzafestas, who is also head of the division. Tzafestas is assisted in this group by an associate professor and five doctoral students. Tzafestas' research activities have been in the area of distributed parameter and large-scale systems, reliability and maintenance optimization, nuclear reactor safety and control, Walsh function techniques, multidimensional systems, robotics, and intelligent systems. He has published 10 books and over 200 papers. He has been guest editor of three special issues on distributed systems and orthogonal functions and was recently guest editor of a special issue on large-scale and complex systems in control theory and application (June 1986). Tzafestas is associate editor of three journals and editor of *International Journal of Modeling and Simulation*.

Tzafestas' recent work has been on distributed-parameter and large-scale systems, on the analysis of parabolic systems via Walsh function, on computational algorithms for algebraic operations on multidimensional polynomials, and on the escalator method for determining optimal state feedback controllers for bordered, unconstrained bilinear systems. During 1986, Tzafestas made some 15 conference presentations.

This group is also involved in an EEC ESPRIT project which concerns tactile sensing for integrated sensor-based robot systems. There is another joint project with the University of Patras which involves the development of novel instrumentation for fault detection and design of reliable controllers for complex systems. Most of the finances for the control research come from the Greek government (*ESN* 41-7:305-388[1987]). The state has also set up an Academic Institute of Communications and Computers with which the division is connected. This institute as well as many others of the same kind have been joined in an effort on the part of the Greek state to bridge the gap between local industry and the level of research in the university--an important function since the doctorate is still considered strictly an academic degree in Greece.

Theoretical Computer Designs. Professor C. Papadimitriou with Associate Professor F. Afrati and five doctoral candidates works in the area of theoretical computer design. Their work is concerned with scheduling and sequencing problems with recent work considering the standard traveling repair man problem and the banker's problem with precedence. Another theme that runs through their work is that of complexity. They have authored articles on the complexity of cubical graphs, on the complexity of recognizing polyhedral scenes, on the complexity of reliability, and on parallel complexity of single-rule programs.

Microelectronics and Applications. There are three professional people in addition to four research associates working in this area. Recent English publications in this area have been by Associate Professor J.N. Avaritsiotis and have been concerned with switching memory effect in hydrogenated amorphous silicon structures, indium-tin oxide thick films for solar cells, and the efficient exploitation of photovoltaic electricity.

Information Systems and Data Bases. Professor J.G. Kollias and three doctoral students are concerned with information systems and data bases. The main problems investigated in this area are concerned with indexed filing system and keyed index sorting--principally with tree structures. Recent publications have considered expected and worst-case storage requirements for quadtrees, multiple-generation text files using overlapping tree structures, batch interpolation search, optimal secondary index organization and secondary index selection, and triply chained tree (an enhancement of doubly chained tree).

Microprocessing-Based Control Systems. The microprocessing controls are in this case applied to heating and air conditioning installations. As might be expected, this group is oriented toward applications. Recent work reported in a conference by research assistant E.A. Kayafas was concerned with automatic temperature management in a building.

Digital Processing of Geophysical Systems. Professor C. Halkias and Associate Professor Kollias with one doctoral student are active in geophysical systems. Their work has been concerned with

the processing of geophysical signals. This processing involves modeling and estimation methods in seismic signal processing and deconvolution and identification of seismic signals.

Digital Signal Processing and Pattern Recognition. This group includes Professor N. Kalouptsidis and a professional staff of five with eight doctoral students. Professors N. Kalouptsidis Kalouptsidis has previously developed a fast algorithm for least square filter and prediction. In more recent work, a unified view of parametric processing algorithms was developed for prewindowed signals.

The VLSI and Signal Processing and Computer Processing of the Greek Language Groups. I have lumped the two last research areas together since the number of people involved is small. In the area of very large scale integration (VLSI), lecturer C. Caraiscos has published material on bit-parallel VSLI implementation of recursive digital filters. In the case of computer processing of the Greek language, Y. Maistros and Y. Kotsani have produced articles on Greek language fundamentals and lexical analysis of Greek.

Conclusions

NUTA's Computer Science Division would be considered a very strong department in any university in the US. The division has an enviable publication record in new areas of investigation. Its director, Professor Tzafestas, is an outstanding university professor with an enviable record, and it is interesting to note the strong influence one person (Tzafetas in this case) can have on the technical level in a given area of research.

The mainframe computer is a Cyber 171. The Cyber is not a virtual memory machine and the computer staff has written some innovative software to improve performance and alleviate this limitation. There are a variety of other computers and devices in the division such as HP 1000, PDP 11/34, VAX 11/750, and a Textronic 4105a color graphics terminal.

I have detailed reference listing for all topics mentioned should there be any further interest.

7/15/87

Electronics

SUPERCONDUCTIVITY RESEARCH AT CAMBRIDGE UNIVERSITY

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

Background

Superconductivity in mercury at a temperature of 4.3 K was discovered in 1911 by Kammerlingh Onnes. By 1973 researchers working with various superconducting materials found that an alloy of germanium and niobium, $N_{b_3}Ge$, was a superconductor at 23.3 K. The next big step did not come until September 1986, when J. Muller and G. Bednorz of IBM Switzerland announced that a mixture of lanthanum, barium, copper, and oxygen had a critical temperature of 35 K, below which it was superconducting. Various researchers have experimented since then with single-phase, doped ternaries of the forms $La_{2-x}A_xCuO_{4-y}$ where A can be barium, calcium, or strontium.

Then, in February 1987 Paul Chu, University of Houston, Texas, achieved a critical temperature of over 90 K with the composition yttrium, barium, copper, and oxygen, $YBa_2Cu_3O_{6.9}$.

The Research at Cambridge

Dr. J.E. Evetts, Department of Materials Science and Metallurgy, Cambridge University, has been carrying out research in superconductivity for more than 20 years. His experience dates back to the time when Brian Josephson at Cambridge invented the Josephson junction, which permitted ultrafast switching at temperatures just above zero K.

Evetts and his group of about 18 researchers have had substantial success in the past with fabricating superconducting wires. They were also the first university group to experiment with thin-film superconductivity. Evetts says, "The prospect of superconducting devices and machines operating in liquid nitrogen and at higher temperatures is seen as an unprecedented technological development. There are potential applications in microelectronics and computers, energy storage and transmission, transport, high-technology engineering, sensors, and instrumentation. For many applications it is essential to prepare these materials in the form of thin films on suitable

substrates. At Cambridge our primary objective has been to achieve the deposition of high-quality thin films."

He went on to point out that:

- Deposition from a multitarget sputter system gives great flexibility and enables casting of a wide parameter net in composition and temperature to ensure early identification of key superconducting phases.
- The deposition and processing of 0.5-μm films can be carried out very rapidly with one or more system cycles per day.
- Measurements on thin films provide quantitative information on basic superconducting parameters and are likely to lead to the first practical applications of these materials.

Evett and his group reported details of their experiments with sputter-deposited YBaCuO thin films.

The samples were deposited on R-plane sapphire substrates placed on a heater at 1050°C in a four-target UHV d.c.-magnetron getter-sputter deposition system. The 0.5- to 0.6-μm films were deposited at a target substrate distance of 120 mm and a rate of 0.2 to 0.3 nms^{-1}. In any one deposition run a range of compositions was produced, varying along the length of the heater. The base pressure was 10^{-7} Pascal (Pa), but with the heater at temperature 1050°C this increased to between 2 and 5×10^{-7} Pa. The outgassing rate of the system remained below 10^{-7} PaS^{-1}. Oxide films were formed using oxygen continuously introduced at 0.08 Pa throughout the deposition. A second method was to deposit a 20- to 30-nm-thick metal film in argon and then introduce oxygen. The oxidation reaction was observed as a fall in oxygen pressure over a period of 5-10 minutes. The sputtering targets, as well as the samples, were oxidized during this time and took several minutes to reach a steady state during subsequent deposition of the next alloy layer.

Table 1

Two-Terminal Resistance Changes Following Various Heat Treatments

No.	Treatment	Room Temperature Resistance (Ω)
0	As deposited	1400
1	5 Min Ar 500°C	129×10^3
2	5 Min O_2 500°C	560
3	5 Min O_2 500°C	590
4	5 Min Ar 560°C	560×10^3
5	5 Min O2 560°C	590

After removal from the deposition system the composition of representative samples was determined using energy-dispersive x-ray analysis on an ISI 100-A scanning electron microscope. Also, a preliminary structural investigation was carried out using x-ray diffraction and transmission electron microscopy (TEM). The composition varied by up to 10 percent along the length of a single 12.5×3 mm^2 substrate. A TEM investigation of one film with an onset critical temperature (T_c) of 75 K indicated the presence of at least two majority phases and up to six minority phases including a hexagonal layer structure. The grain size was of the order of the film thickness in the high T_c region of the film.

Analysis of the variation of the resistive transition with composition leads to the conclusion that the high T_c phase is $YBa_2Cu_3O_7$. From observation the highest T_c in any given run always has a composition with Y:Ba ratio 1:2 and Cu in the range 55-60 percent. The compositions surveyed in the Cambridge study ranged from $Y_{0.3}Ba_{0.1}Cu_xO_y$ to $Y_{0.1}Ba_{0.3}Cu_xO_y$ with x between 0.4 and 0.85.

There is good evidence that a substantial proportion of the material is superconducting, and behaves in a manner consistent with that of the perovskite layer structures. A sample with mean composition $Y_{0.17}Ba_{0.34}Cu_{0.5}O_y$ showed a superconducting transition onset at 90 K, and fully superconducting at 36 K.

One significant characteristic of these compounds is the reversible uptake of oxygen and associated changes in electrical conductivity. Table 1 shows the reversibility and the dramatic decrease in conductivity, with oxygen depletion resulting from a series of heat treatments.

The superconducting transition was measured before and after this series of treatments. Before heat treatment the sample has a T_c onset of 20 K and was only partially superconducting at 4.2 K. After the final oxygen anneal it had a T_c onset of 75 K and was found to be fully superconducting at 15 K. Annealing and reversibility experiments were essentially complete after 5 minutes at 500°C, indicating the potential value of thin-film samples in studying these compounds.

A further demonstration of the unusual behavior of these materials is seen from a 1-minute immersion in water. This completely, and apparently irreversibly, transformed the black conducting film into a largely transparent and insulating layer. This behavior, together with the reversible oxygen uptake, indicates the presence of extremely active defect sites within the crystal lattice.

The Cambridge Group has observed complete superconductivity in materials with measured Y:Ba ratios between 1:1.6 and 1:3. The sharpest transitions have been obtained from samples with the composition $Y_{0.17}Ba_{0.34}Cu_{0.50}O_y$.

The group's results have demonstrated the practical deposition of high T_c-oxide films and give a strong indication of the composition of the high T_c phase. Their future work will aim to increase film homogeneity and perfection to enable them to carry out basic measurements, investigating the effect of additives. They also plan to fabricate tunnel junctions and devices.

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7/25/87

Material Sciences

RESEARCH ON FUEL CELLS AND MOCVD AT IMPERIAL COLLEGE

by Robert Vest. Dr. Vest was the Liaison Scientist for Electronic Ceramics and Materials in Europe and the Middle East for the Office of Naval Research's London Branch Office until August 1987. He has returned to Purdue University, where he is Turner Professor of Engineering in the School of Materials Engineering and in the School of Electrical Engineering.

Introduction

A wide variety of research activities in electronic ceramics are currently underway in the Department of Materials at Imperial College of Science and Technology in London. These include (1) properties and metalization of AlN ceramics; (2) electrical behavior of grain boundaries in ZnO varistors; (3) solid-state electrochromic systems for variable transmission windows; (4) ceramic/polymer composites for dielectric applications; (5) development of buried dielectric layers; (6) diffusion in SiO_2 and Si_3N_4 insulating layers; (7) ceramic superconductors; (8) solid-state electrochemical reactors incorporating ceramic oxide electrolytes for partial oxidation reactions; (9) solid oxide fuel cells; and (10) properties of oxide dielectric layers produced by metal organic chemical vapor deposition (MOCVD). This report will discuss activities in the last two areas.

Solid Oxide Fuel Cell Research

Professor B.C.H. Steele has been a world leader in research on solid electrolytes for the past 20 years, and his group is currently the major participant in a new research and development program on solid oxide fuel cell (SOFC) systems supported by the ECC. This program, which involves nine laboratories in six European countries, has as its objectives the fabrication and evaluation of small (~50 W) multichannel SOFC reactors, accompanied by research on preparation and characterization of alternative ceramic oxide electrolytes that will improve the low-temperature (700-800°C) performance of SOFC systems, and optimization of electrode materials/structures. The experimental research has just started (1 June 1987), so my report will describe planned rather than completed research, but this is an exciting program that should be closely followed by anyone interested in solid electrolyte materials and devices.

Steele's group is utilizing recent advances in ceramic fabrication technology to produce multichanneled honeycomb reactors (Figure 1) with zirconia-yttria electrolyte compositions. This new design for SOFC has a high surface area to volume ratio (>10 cm^2/cm^3) which should enable volumetric power densities to approach 1 kW/liter. The initial stage of the program will use small reactors containing approximately 100 channels with an active surface area of 50-100 cm^2, which will limit power generation to a few watts. These honeycomb reactors will be used to provide information on several pertinent aspects of the technology. One of the areas of research will be on methods for incorporating the electrode structures and current leads into the adjacent air/fuel channels. The group is going to investigate a number of deposition methods for the electrodes, including sol-gel, chemical vapor deposition, and metallo-organic decomposition. Particular attention will be given to the adhesion of the porous electrode structures to the impermeable zirconia

electrolyte channel walls when the assembly is subjected to thermal cycling.

A recognized problem with SOFC systems is the relatively poor electronic conductivity associated with the cathode material; $La_{0.8}Sr_{0.2}MnO_3$ is usually selected for this application. One possibility to overcome this problem is to utilize a multichannel corrugated design, as shown in Figure 2, but a more satisfactory solution, at least from a materials scientist's perspective, is to use oxide systems which exhibit considerably higher electronic conductivity at the operating temperatures than the ones currently in use. One class of materials that will be investigated for this application are the rare earth-alkaline earth-copper oxides, which have aroused such intense interest as high-temperature superconductors.

Alternate electrolyte compositions will be required in order to develop SOFC reactors operating at 600-800°C. Steele's group will study a series of tetragonal stabilized zirconias (e.g., ZrO_2-Y_2O_3, ZrO_2-Er_2O_3, ZrO_2-CeO_2-Y_2O_3, etc). These indicate only a few of the problems that must be solved in order to make significant progress in SOFC systems. The group at Imperial College has the talent and proven track record that gives hope that these problems will be solved.

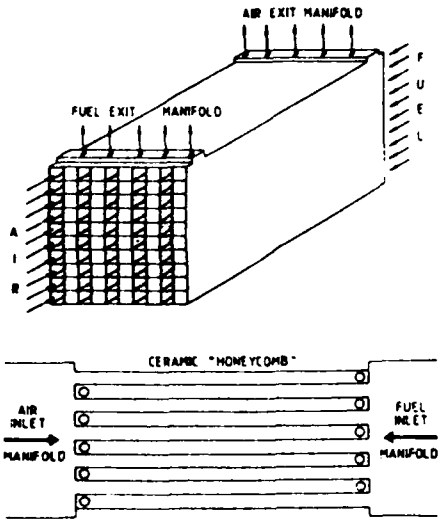

Figure 1. Multichannel honeycomb reactor.

MOCVD

The group headed by Professors B.A. Unvala and E.A.D. White has developed some innovative techniques and experimental reactors for depositing semiconductor and oxide films by MOCVD. A major strength of their program is the collaboration of Professor D.C. Bradley of the Chemistry Department at Queen Mary College, London. Professor Bradley synthesizes and characterizes the precursor compounds used in the MOCVD research.

The group has grown films of GaN by vapor phase epitaxy using the reaction between trimethyl gallium (TmGa) and ammonia, which is nothing new. What is new is their procedure for the safe *in situ* generation of TmGa using di(TmGa).1,2-bisdiphenylphosphinoethane (TmGa DIPHOS) adduct. The TmGa DIPHOS adduct when heated gives TmGa, which is gaseous, plus DIPHOS, which is a solid, and the equilibrium partial pressure of TmGa is a function of the temperature. The TmGa DIPHOS is heated in a glass vessel, which by virtue of its construction meters precise quantities of TmGa into the reactor system. The reactor is equipped with a microwave-induced remote plasma generator and a xenon-mercury arc lamp system for studies of low-temperature growth under plasma and photolytic enhancement in order to reduce lattice vacancies in the GaN. The data they have obtained to date indicate that very high quality GaN films can be produced by this procedure.

A different type of reactor is used to produce films of Al_2O_3, TiO_2 and Nb_2O_5.

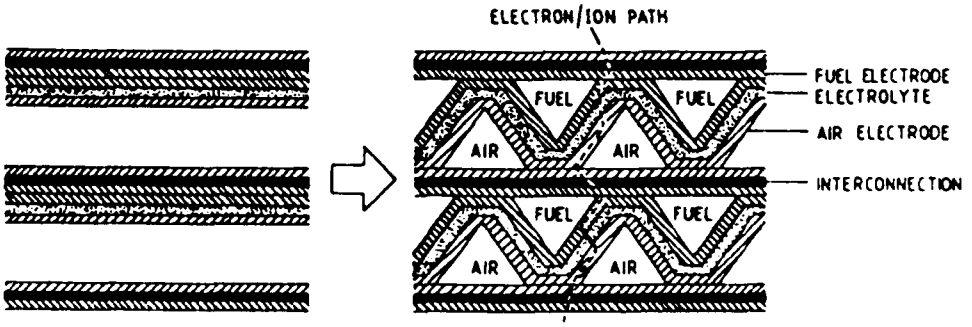

Figure 2. Multichannel corrugated reactor.

This reactor involves a system for injecting the organometallic precursor dissolved in an inert solvent through a high-voltage atomizing nozzle to produce a stream of charged micron-size droplets. The system involves a microwave-induced plasma generator and a xenon-mercury arc lamp system for studies of plasma and photolytically enhanced decomposition. Their current research involves studies of the formation of $PbTiO_3$ and Nb_2O_5-TiO_2 compositions using this reactor system. They plan to extend their research on oxide films by MOCVD to studies of superconducting films such as $LaBa_2Cu_3O_7$.

Summary

The Department of Materials at Imperial College has made many contributions to research in electronic ceramics over the years. Their current research activities are in some of the most important and exciting areas in electronic ceramics, and should keep them in the forefront for the foreseeable future.

7/22/87

COMPOSITE MATERIALS CONFERENCE IN FRANCE

by Louis Cartz. Dr. Cartz is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Marquette University, College of Engineering, Milwaukee, Wisconsin.

The "Association pour les Matériaux Composites" (AMAC) organizes a regular series of conferences in France on composite materials. An AMAC meeting on the "Physical Chemistry and Mechanical properties of the Fiber-matrix Interface" was held in December 1986 at the Office National d'Etude et de Recherches Aérospatiales (ONERA), Chatillon, Paris, in cooperation with a meeting, "Chemistry of Composites," given by the Group Recherche Coordonné (GRECO) of the Center Nationale de Recherche Scientifique (CNRS).

Conference on the Fiber-Matrix Interface

About 100 scientists were present at this 1-day meeting, held in the special conference hall of ONERA. The proceedings were in French and all the participants were from France. Studies of the behavior of the matrix fiber interface were described using a wide range of techniques, and these are reviewed in this report.

Acoustic Emission Testing

D. Rouby (Institut National des Sciences Appliquées, [INSA] Lyon) gave a very interesting discussion of the application of acoustic emission (AE) testing to study the rupture of a fiber in a matrix under tension. The specimen consisted of a single fiber of carbon, along the specimen axis, in a matrix of epoxy. The fiber is subjected to a series of fractures, each of which gives rise to an AE signal. By observing simultaneously the stress/strain diagram, the investigator can relate the individual AE pulses to the individual jumps in the stress/strain curve.

The position of the fracture along the length of the carbon fiber can be determined by using two detectors, one at each end of the fiber specimen. It is found that fracture of the fiber occurs at random positions along the fiber. The shape of the AE pulse provides information about the time interval for the fiber rupture to occur and corresponds to $\sim$700 ns. This seems to be related to the time taken for the release of the ruptured carbon fiber from within the epoxy matrix. Rouby concluded that the fiber rupture was not related to the pre-existence of defects in the carbon, and that data on the interaction fiber/matrix can be derived from the shape of the AE pulse.

Electron Microscope Studies

Mme. Guigon (University of Technology, Compiègne) has studied the penetration of organic matrices into treated surfaces of carbon fibers by transmission electron microscopy (TEM). Guigon examined two types of fibers: Courtauld high-resistance fiber (HT) and Courtauld high-modulus fiber (HMU). Several surface treatments were used including application of aqueous solution $(NH_4)_2SO_4$, hexamethylene tetramine, picoline, and urea, and also surface treatments by a plasma of N_2. After surface treatment, the fibers were sealed in a resin, ultramicrotoned to give transverse slices $\sim$700Å thick, then examined, by TEM, using lattice fringe methods.

Guigon examined the surface-treated fibers before imbedding when a disorganized carbon layer is observed about the graphitic fibers. She showed various views of the interface after the different surface treatments. She attempted to distinguish between adhesion, by atomic bonding, and adherence, a macroscopic phenomena. Interpenetration of the matrix into pores could be observed in the TEM. She concluded that a light degree of treatment with ammonium sulfate or hexamethylene tetramene gave rise to a good penetration and good adherence. The

other treatments gave rise to less adherence; it was very poor in the case of nitrogen plasma. These results agree with the known mechanical behavior of such composites. Some industrial carbon-fiber-composite specimens were also examined and these showed two interfaces, one intimate with the carbon fiber surrounded by a second interface in the matrix. Guigon was questioned about degassing effects, the pore sizes (said to be 10-25 Å), and the penetration of carbon asperities into the resin.

Surface Energy Measurements

A general review of acceptor-donor interactions at the fiber matrix interface was given by J. Schultz (CNRS, Mulhouse). He has determined angles of wetting as the fiber passes from air to a liquid hydrocarbon to a solution of formaldehyde. This permits the surface energies, $\gamma(s)$, to be measured where $\gamma(s) = \gamma(\text{donnor}) + \gamma(\text{acceptor})$, and $\gamma(s)$ are found to be of the order of 50 mJm^{-2}. He used carbon fibers from polyacrylonitrile, PAN, determining $\gamma(s)$ after different surface treatments, such as oxidation and coatings.

Another method of determining $\gamma(s)$ uses the inverse chromatographic effect (at infinite dilution) which permits an estimate of the acceptor-donor adhesion effects between the matrix monomer and the carbon fibers of the chromatic column.

Forced Vibrations Measurements

J.F. Gerard (Université Claude Bernard, Villeurbanne) reported on his studies of the interface behavior between carbon fibers and epoxy matrix by mechanical vibrational methods, using forced vibrations of plates of composites containing unidirectional continuous carbon fibers. He performed internal friction-type measurements of loss-factors and their dependence on temperature. Forced vibrations were carried out in both flexural and shear modes. He compared the viscoelastic properties of the epoxy matrix to those of the composite for different surface treatments of the carbon fiber such as coatings and oxidation. He also compared the visoelastic properties of the epoxy matrix to those of an epoxy reinforced by a glass fiber. These measurements permited *in situ* observations of the interface behavior. The coated carbon fibers at high amplitude of vibrations behave differently from the glass fibers, which undergo permanent damage, while the coated carbon fibers can reverse their behavior with no permanent damage. Gerard explained this as being due to the breaking of the atomic bonds in the glass fibers (a permanent effect) while in the carbon fibers the physical interaction between fiber and matrix does permit the interface to recover.

Crystallization of the Polymer Matrix

J. Cinquin (Université Claude Bernard, Villeurbanne) related the shear stress behavior of polyamide matrices reinforced with glass fibers to the degree of crystallization of the polymer, and to the nature of the coatings of the glass fibers. Cinquin followed the matrix crystallization by differential scanning calorimetry (DSC) and by x-ray diffraction. He concluded that the glass fibers act as nucleation centers so that above 50-wt-percent fiber, a secondary crystallization effect occurs with the matrix having a higher degree of crystallinity than would be the case for pure matrix. The shear modulus of the composite increases with the degree of the crystallinity of the matrix polymer.

Composites of Silicon Carbon Fibers in Titanium Alloys

The mechanical properties of composites of silicon carbide filaments in a matrix of titanium alloys was examined by R. Pailler (University of Bordeaux). The silicon carbide filaments were prepared by chemical vapor deposition (CVD) on carbon or tungsten filaments, resulting in thick filaments with diameters of the order of 100 μm. The titanium metal alloy used contained 6 percent aluminum and 4 percent vanadium. The mechanical properties were compared with the nature and thickness of the surface treatment of the fibers. The composite was prepared by hot pressing rafts of silicon carbide filaments between foils of titanium alloy at temperatures ranging from 800-950°C pressures of 70-150 MPa, and for times of 10-60 minutes. Pailler examined the microstructure of the phases at the interface using x-ray diffraction, scanning transmission electron microscopy (STEM), Auger spectroscopy, and x-ray microprobe analysis. The Young's modulus, the modulus of rupture (MOR), and yield point are being determined for the composites. The presence of a protective layer about the fiber was shown to be important.

Fragmentation Testing

L. Grateau (ONERA) applied a fragmentation test to fiber matrix bonding in ceramic-ceramic composites such as silicon carbide fibers in silicon carbide matrices and silicon carbide fibers in Al_2O_3 matrix. A single fiber in the matrix is subjected to a tensile stress. Fragmentation occurs either of the fiber or of the matrix depending on whether the strain at rupture is greater in the matrix (fracture of the fiber case) or is

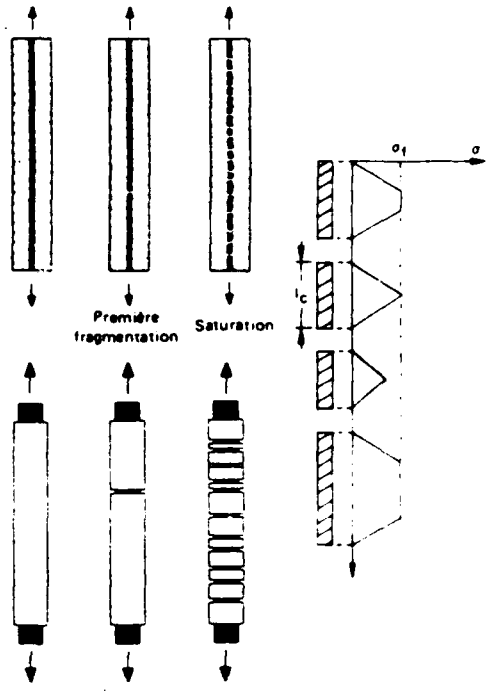

Figure 1. Schematic of the process of progressive fragmentation. The longitudinal stress σ is transmitted by shearing along the matrix fiber interface. For a fragment of length l_c, the stress in the fiber (or matrix) is just equal to the rupture stress (σ_f).

greater in the fiber (rupture of the matrix case). For ceramic-ceramic composites, it is fragmentation of the matrix which is likely to occur. The critical length of the fragments is such that the stress level never attains the rupture level (see Figure 1). In fragments having a critical length l_c, the stress in the fiber (or matrix) is just equal to the rupture stress, σ_f. Measurements of fragment sizes show them to be smaller for coated fibers. In the case of silicon-carbide/silicon-carbide composites, oxidation of the fibers provides a coating. It is found that fragmentation can occur either in the fiber or in the matrix, depending on the temperature; the different results depend on the ability of the matrix fiber interface to undergo shear or to separate.

Critical Shear Stress Between Fiber and Matrix

Using a simple microindentation technique, D. Rouby (INSA, Villeurbanne) attempted to determine the critical shear stress between fiber and matrix. This shearing effect between fiber and matrix is considered to be most important in determining behavior of the composite. When rupture occurs of a fiber in a matrix, or of the matrix about the fiber, there is a zone of shearing between fiber and matrix. Composites of silicon-carbide/silicon-carbide (from Société Européene de Propulsion) and silicon-carbide/SiO_2 (from Aérospatiale) were examined. Rouby prepared the surface by exposing the cross section of a fiber and placed the load on the fiber by use of a microindentor. The fiber was depressed within the surrounding matrix by a distance u. Assuming a model of shearing under constant load, Rouby showed that u is related to the applied load, the fiber radius, Young's modulus of the fiber, and ζ (the critical shear stress at the interface). The depression can be measured with an SEM. The critical shear stress for SiC-SiO_2 is found to be 8±3 MPa and for silicon-carbide/silicon-carbide ζ = 57±17 MPa.

Fiber Coatings and Fracture

A paper on the effect of fiber coatings on the fracture characteristics of composites of silicon carbide fibers in Pyrex glass matrix, silicon carbide fibers in glass ceramic matrix, and silicon carbide fibers in Al_2O_3 matrix was given by P. Pérés (ONERA). Small plates of these composites were submitted to three-point testing. The silicon carbide fibers (Nicalon) were coated with 300-500 Å of carbon by CVD. From the stress-strain diagrams, the fracture stress increases to approximately twice the value when using treated fibers as compared to untreated fiber under identical testing conditions.

The silicon-carbide/glass ceramic composite uses a lithium aluminum silicate glass ceramic (LAS) developed by St. Gobain containing ZrO_2 and Nb_2O_5. A unidimensional composite is prepared at 1310°C and pressures of 16 MPa for 20 minutes, giving a density of 2.4 Mgm^{-3} with a volume fracture of fibers of 34 percent. Stress-strain cyclic testing was carried out. The best composite is not necessarily one in which the adhesion between fiber and matrix is the best.

Other Papers

A. Michel (CNRS, Vernaison) described the behavior of short glass fibers coated with a polymer containing side-chains in a polymer matrix; the intention was to augment the adherence of the fiber to the matrix.

B. Capdepuy (Aérospatiale, St. Médard-en-Jalles) is carrying out three-point flexural tests, comparing composites with alumina matrices derived from sol-gel methods with those from slip-casting methods. The composites studied

are (1) Al_2O_3 fibers (Sumitomo) in matrices of sol-gel alumina, (2) Al_2O_3 fibers in slip-casting alumina, (3) Al_2O_3 in $85Al_2O_3.15SiO_2$, and (4) silicon carbide fibers (Nippon carbon) in matrices of sol-gel Al_2O_3 and also in matrices of slip casting Al_2O_3.

Conclusion

Several workers presented their studies of the shearing of the fiber-matrix interface at the rupture point and how this can be changed by fiber surface treatments such as coatings or oxidation. Studies of the interfacial shearing were carried out by acoustic emission, forced vibrational methods, fragmentation, and microindentation testing.

Different surface treatments of the fibers were tried, including carbon coatings by CVD, nitrogen plasma surface treatment, and various chemical agents. The interface microstructure was examined by TEM using lattice fringe methods, and surface energies of the interface were measured along with critical shear stresses. The effect of the matrix on the interface was investigated including changes in the crystallinity of the matrix polymers, the microstructure of a titanium alloy matrix, and the method of preparation of alumina by sol-gel as against slip casting.

The meeting covered most of the important aspects of the fiber matrix interface. This is indeed the intention of the CNRS organization GRECO--the coordinating research group--on the chemistry of composites.

7/29/87

Mechanics

PROSPECTIVES IN TURBULENCE STUDIES--AN INTERNATIONAL SYMPOSIUM

by Eugene F. Brown. Dr. Brown was the Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office until September 1987. He has returned to the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

An international symposium entitled "Prospectives in Turbulence Studies" was held at the Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt (DFVLR) in Göttingen, West Germany, on 11 through 12 May 1987 in honor of the 75th birthday of Dr. J. C. Rotta. Dr. Rotta, a DFVLR employee since 1945, has made many outstanding and original contributions to the field of turbulent boundary layer research including the publication of a monograph and a textbook on turbulence, which have become classical reference works in the field. The program consisted of invited presentations by 15 turbulence experts from western Europe, the US, the USSR, the People's Republic of China, Japan, and Australia. The meeting was attended by approximately 130 scientists and engineers with the majority coming from West Germany. A 500-page proceedings, containing complete versions of each of the 16 presentations, was published by Springer-Verlagand and distributed to the participants at the beginning of the meeting.

The following topics were covered in the course of the symposium (although the presentations were not organized this way):

- Laminar/turbulent transition in boundary layers
- Coherent structures in the modeling of turbulent boundary layers, wakes, and jets
- Experimental facilities and techniques
- Calculation methods for turbulent flows.

Laminar/Turbulent Transition

In his review paper, J.T. Stewart (Imperial College, UK), pointed out that despite the impressive accomplishments of nonlinear stability theory over the past 10 years, several questions regarding the detailed mechanism of the transition process remain unanswered. Among these questions are:

- What is the connection between the Klebanoff-Kovasnay mechanism of transition and the resonance mechanism?
- What is the mechanism for the development and aglomeration of turbulent spots?

W. Saric (Arizona State University, Tempe), in his presentation on the stability of three-dimensional boundary layers, added three more questions to this list:

- What range of three-dimensional disturbances is most unstable and what kind of interaction between disturbances is possible?
- What are the mechanisms involved in the interactions?

- And (perhaps the most fundamental question of all), how do we define transition?

Answers to these questions will be easy to come by. As Saric pointed out, the cross-flow instability, which in many cases is responsible for the initiation of transition, is very dependent upon initial conditions; and, moreover, visualization techniques which at first glance appear to be relatively benign (such as trichloroethelene coating) can actually change the nature of the flow. Clearly, as Saric observed, "We are a long way from being able to predict transition," and, he concluded, "We have not even begun to discuss the roles of unsteadiness, strong pressure gradients, the effects of surface roughness, and curvature."

A paper by H.U. Meier, DFVLR-Göttingen (West Germany) provided experimental verification of the sensitivity of the transition process to initial conditions. Meier reported results obtained from transition tests conducted on DFVLR's 2.4-m×0.4-m prolate spheroid in three European wind tunnels: the low-speed wind tunnel at DFVLR-Göttingen, the low-speed wind tunnel at DFVLR Braunschweig, and the German/Dutch wind tunnel in the Netherlands. The region of transition was taken as the region in which a strong increase in skin friction coefficient occurred as measured by 12 flush-mounted surface hot-film probes. Depending upon the facility in which the experiment was conducted, the point at which transition began (at a fixed value of the free-stream Reynolds number) varied from 40 percent to 75 percent of span. Some consolation can be had from the fact that to a certain extent this variation can be attributed to differences in the power spectral density of the axial turbulence fluctuations in the various facilities. Saric, however, cautioned against assuming that this was the only source of discrepancy since it should be expected that the normal and cross-flow fluctuating velocity components (which were unmeasured in these tests) will also affect the transition process.

A heat-pulse technique which offers an alternative to the classical vibrating ribbon technique used by Schubauer and Skramstad was described by Zhou Ming of the Nanjing Aeronautical Institute, (China) in a collaborative study between the DFVLR and the Chinese Aeronautical Establishment. The heat pulse was provided by either a single 15-mm-long wire at the center of a plate (see Figure 1) or a 2-row array of 12 wires. The response of the flow to the pulse was measured by a series of surface hot-film probes. Tests carried out in DFVLR-Göttingen's 1.5×0.3-m^2 low-turbulence wind tunnel verified the results of the Orr-Sommerfeld theory for the early stages of laminar/turbulent transition, and revealed that transition begins with the so-called "K" pattern. He found that the maximum amplification of disturbances occurs at oblique wave angles, which agrees well with Craik's resonant triad theory. The advantage of the heat-pulse technique is that it appears to offer sharper spectral response (particularly of the second harmonic) than does the vibrating ribbon technique.

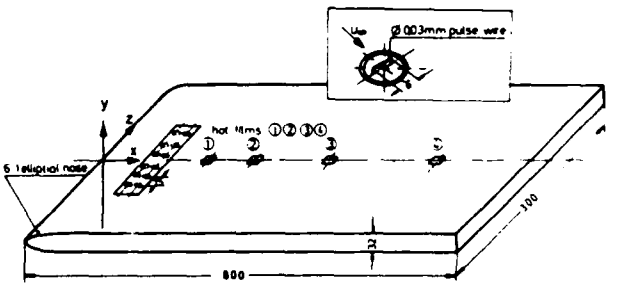

Figure 1. Flat plate model with heat-pulse wires and surface hot films (dimensions in mm).

Coherent Structure Considerations

First discovered by Brown and Roshko, coherent structures are vortical parcels of fluid in a turbulent boundary or shear layer in which distinct phase relationships exist between the flow variables. Previously, turbulence was understood to be a chaotic or irregular process, a conception which arose from the fundamental experiments of Osborne Reynolds, who suggested that the flow field could be described as consisting of a mean velocity field upon which stochastic temporal fluctuations were superimposed. This method provided the basis for the statistical theory of turbulence which has dominated the field for more than 40 years. Perhaps the most important aspect of the discovery of the existence of deterministic features (the so-called coherent structures) in turbulent flows is the possibility of controlling turbulence by means of direct interference with these structures. There remain, however, unresolved questions about what these coherent structures look like and what connection, if any, there is between their appearance and the location of local maxima or minima in intermittency, boundary layer thickness, and skin friction.

To answer some of these questions, D. Coles (California Institute of Technology, California) reported on an experiment which he performed on what he

called a synthetic turbulent boundary layer. By a synthetic turbulent boundary layer Coles means a flow which is produced by generating a regular array of turbulent spots in an otherwise laminar boundary layer. In his most recent experiments the disturbances were produced near the leading edge of a flat-plate by a two-lobed camshaft which projected a small hexagonal pattern of pins momentarily through the plate and into the flow. These experiments were done in air at a free-stream velocity of 12 m/s. The velocity and skin friction directly downstream from the pins was measured with a crossed hot-wire probe and heated surface elements respectively. Analysis of the more than 3 megabytes of data which was collected during the study revealed that the coherent structures have a fingerlike appearance with the fingers pointing in the downstream direction grouped together in a form resembling a slightly inflated rubber glove. This contrasts with the view held by Moin and others (*ESN* 40-3: 98-100 [1986]) in which the coherent structures are regarded as having an appearance like a hairpin or horseshoe. In fact these two interpretations of the nature of coherent structures may well be complementary. As Coles suggested, the hairpin structures may well be the ribs around which the fingerlike structures are built. Coles contends, however, that it would be a mistake to confuse the hairpin vortices with the coherent structures. Coles also discovered that the peak in the skin friction leads the peak in boundary layer thickness by about 70 degrees, and the peak in the wake component lags the peak in the boundary layer thickness by about 190 degrees. Coles considers this work, which is reported in greater detail by O. Savis (Savis and Coles, 1985) and Savis and J. Arakeri (a California Institute of Technology dissertation to appear this year), to be a major contribution to the subject of coherent structure. It is the culmination of 13 years of his research on this topic.

Rather than using the variable integration time averaging (VITA) technique to detect coherent structures as was done by Coles, it is possible to use acoustic stimulation to stabilize the coherent structures so that they may be visualized by, say, a light-sheet technique. Such studies were described by V. V. Kozlov (Institute of Theoretical Applied Mechanics, Soviet Academy of Sciences, Novosibirsk, USSR). In experiments in the wake of a flat plate, airfoil, blunt body, step, and jet in cross-flow he examined various frequencies of excitation and studied their effect on the flow field with a hot-wire probe.

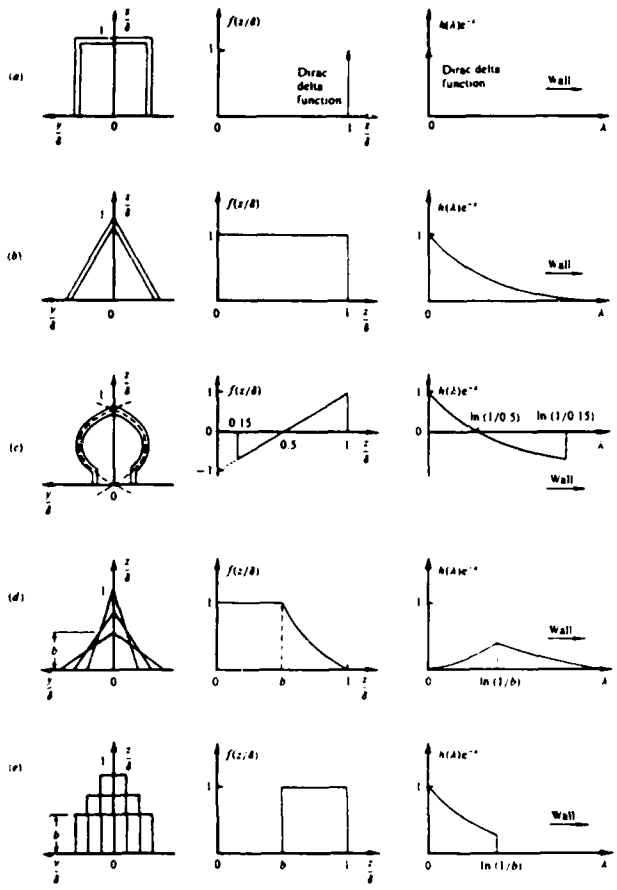

Figure 2. Proposed eddy shapes of coherent structures and accompanying vorticity intensity functions.

One of the uses of the coherent structure concept is that it might provide an alternative to such methods as the mixing length theory for predicting the behavior of turbulent flows. A. Perry (University of Melbourne, Australia) explored this possibility by constructing various models of the hairpin vortices which he, like Coles, regarded as subelements of coherent structures. Perry deduced the detailed structure of the hairpin coherent substructures by considering various candidate eddy geometries (see Figure 2), and for each of the candidate eddy shapes he calculated the local mean velocity by assuming an inverse power law probability density function for the vortical scales found in the eddy. His conclusion was that only the bow-legged-shaped eddy (labeled "c" in Figure 2) produced the expected Coles law-of-the-wall-and-wake velocity profile. In addition, he found relationships

between the mean flow and the Reynolds stresses. The universal nature of these relationships, however, rests with the universality of the bow-legged eddy structure. If, under the action of a pressure gradient significantly different eddy shapes are found, the usefulness of this technique as a predictive tool might be rather limited.

Experimental Facilities and Techniques

Despite considerable progress made in the direct (numerical) simulation of turbulent flows, careful collection and analysis of experimental data continues to be a key element in improving our understanding of turbulence and laminar/turbulent transition. R. Narasimha (Indian Institute of Technology, Bangalore) presented his contention that the earth's atmosphere provides a medium in which such experiments can be conducted. It is his belief that the earth's atmosphere can be regarded as a cheap, high-Reynolds number wind tunnel where boundary layer studies can be conducted at Reynolds numbers exceeding those obtainable in a laboratory setting by more than 4 orders of magnitude. He supported this contention by analyzing a set of data taken in the atmospheric boundary layer at the Boulder Atmospheric Observatory in Boulder, Colorado, by means of the VITA technique, a well-known method for detecting bursting events in laboratory-scale experiments. He observed that:

- The shear velocity in the atmospheric boundary layer was approximately 1 m/s or approximately the same value obtained in laboratory-scale tests.
- The characteristic time of the burst period seems to agree better with "outer scaling" than with "inner scaling," verifying a belief held by Narisimha for some time.
- The high Reynolds number of the atmospheric boundary layer produces bursting events which are much more prominent than in laboratory-scale flows, but, because of the larger outer scale of the atmospheric boundary layer, occur at a rate of only 10^{-4} of that found in the laboratory.
- Finally, in looking at the details of the bursting events and comparing them with similar events in the laboratory, Narasimha found that the low threshold at which event frequencies occur in the atmosphere are comparable to those found in laboratory flows.

Narisihma concluded, insofar as he was able to determine after making proper allowance for Reynolds number effects, that the phenomena of bursting in an atmospheric boundary layer was, in all respects, identical to that found in the laboratory and consequently that the atmosphere serves as a reliable model of high Reynolds number turbulence. As was made clear after the presentation, however, care must be exercised to assure that atmospheric conditions are such that neutrally stable (thermal) atmospheric boundary layer conditions exist so that buoyancy effects are not involved.

A much more conventional way of using the atmosphere to obtain experimental data is flight testing. In this connection, A. Bertelrud of the Aeronautical Research Institute of Sweden (FFA), described his experience in using flight experiments to study three-dimensional shear layers. The principal drawback of flight experiments is that they are an order of magnitude more expensive than experiments conducted in the laboratory. In addition, they require specialized test equipment (a suitable airplane and a competent pilot, for example) which might be very difficult for the average experimenter to obtain. Bertelrud's principal point is, however, at centers such as FFA in Sweden which have such aircraft and the facilities required to maintain them, the availability of today's high-quality, air-worthy instrumentation makes the collection of near-laboratory-quality data a feasible and desirable proposition. The desirability of flight experiments, of course, rests in their freedom from the effects of wind tunnel turbulence and wall interference and the absence of any need to extrapolate the data (in Reynolds number, for example) to simulate actual flight conditions.

After describing a number of flight tests, beginning in the 1930's, in which fundamental fluid mechanics data was collected, Bertelrud went on to describe in detail the 5-year FFA flight test program using a SAAB 32A Lansen. Figure 3 shows the variety of instrumentation used in the course of these tests. Bertelrud contends that an important ingredient of reliable flight testing is the existence of multiply redundant instrumentation to aid in the correct interpretation of the data. For the measurement of the local skin friction, for example, he used four different types of probes. Of particular interest to Bertelrud was the experimental characterization of the leading edge flow, regions of massive and partial span separations, shock-wave/boundary-layer interaction, and buffeting. In addition, he conducted experiments to examine the effectiveness of large eddy break-up (LEBU) devices, passive shock control through surface perforation (see ONRL Report No. C-2-86), and attachment-line transition trips. An outstanding feature of these experiments was the manner in

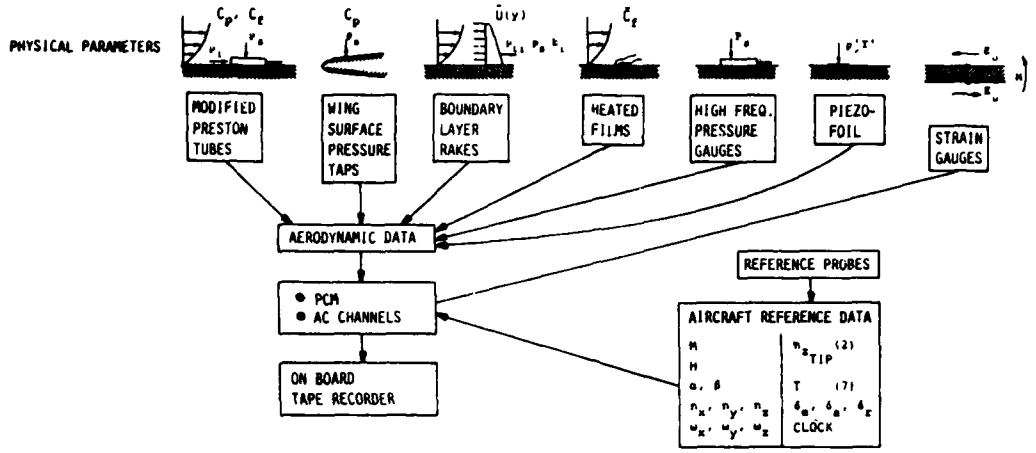

Figure 3. Sensors and data acquisition system for in-flight measurements.

which the data was stored. Care was taken to archive the data in a data-base fashion so that the results could be easily accessed and retrieved for subsequent study. The data base and the programs which allow access to it are available from the FFA.

For more than 30 years hot-wire anemometry has been used to measure the mean and fluctuating turbulent velocity components in boundary and shear layers. U.R. Müller (Messerschmidtt-Bölkow-Blohm, Bremen, West Germany) described recent advances in hot-wire techniques with particular attention to the measurement of Reynolds stresses and compared the use of hot-wire anemometry to the newer laser Doppler anemometry (LDA) technique. A particularly useful probe for making such measurements is the so-called three-wire probe using mutually orthogonal hot-wire sensors. With such a probe, instantaneous velocities as well as mean velocities, Reynolds stresses, and higher-order correlations of the fluctuations can be conveniently obtained from one set of measurements. The advantage of the orthogonal configuration is that signal interpretation by matrix inversion is unique throughout the acceptance range.

For high-turbulence levels (turbulence intensities greater than 40 percent) and in regions of recirculating flow, conventional hot-wire measurements are impossible. This is because the standard hot-wire technique provides only the velocity magnitude and not its direction. To obtain this, techniques such as the flying hot-wire have been developed in which the probe is moved at high speed through the flow field. Another approach is to sense the direction in which the thermal tufts produced by the hot-wire are convected. Recently Müller (1983) has proposed a way in which the thermal tuft principle can be used in conjunction with a triple wire probe.

The hot-wire technique is not well suited for measurements in compressible flows. This is because the hot-wire signal is a function of the product of velocity and density. In compressible flows both the velocity and density are unknown and no really successful way has been found to uncouple these effects. Under these conditions LDA is the method of choice. For the present, hot-wire anemometry and LDA will coexist as complementary tools for experimental turbulence research; however, Müller predicted that in the future LDA will be used even where hot-wire anamometry can be successfully employed. The reasons for this lie with the geometrical complexity of three-dimensional hot-wire probes and with computational complexities involved in reducing hot-wire data, particularly in regions of recirculating flow.

Calculation Methods for Turbulent Flows

Considering the unsatisfactory nature of our knowledge of the laminar/turbulent transition process and of the structure of turbulent flows it may seem to some that the title of this section is more than a bit presumptuous. From an industrial perspective, however, computational methods using empirically based turbulence models and transition criteria have been found to be so effective in reducing the design time of new aircraft and missile systems that design codes containing turbulent boundary layer calculations have become a vital tool of the design engineer. In such applications one is willing to overlook what must, in the context of this meeting, be regarded as fundamental physical deficiencies in favor of the time savings which numerical simulations offer in comparison with wind

tunnel or flight testing. This was certainly the motivation behind the applications described by W. Schmidt of Dornier GMbH, Friedrichshafen, West Germany. It must be remembered that in the design process absolute accuracy in many situations is far less important than the ability of a code to properly predict the consequences of various configurational changes. It was in this spirit that many of the computational applications (ranging from transonic wing performance to hypersonic reentry problems) were presented.

Those farther removed from the design process can and should view current computational procedures in a more critical and dispassionate way. An outstanding example of such a critical assessment of modern practice for the computation of three-dimensional turbulent boundary layers was provided by J. Cousteix of the Office National d'Etudes et de Recherches Aérospatiales Toulouse, France. Depending upon the boundary layer method used, various problems arise. For example, if the integral boundary layer equations are used, it is not at all clear how cross-flow velocity profiles should be modeled, what to use for the entrainment coefficient, and what to do about the absence of a three-dimensional version of the law-of-the-wall. If the Navier-Stokes equations are solved instead of the boundary layer equations, new difficulties arise. What turbulence model should be used? How should the normal pressure gradient be handled, particularly in flows involving separation? How can an anisotropy be introduced into the calculation of the eddy viscosity?

Other questions arise which are common to both boundary layer and Navier-Stokes calculations such as what to do about transition. In three-dimensional flows three mechanisms promote transition: cross-flow instabilities, streamwise instabilities, and leading-edge contamination. In addition, sometimes a relaminarization occurs. Unfortunately, only empirical criteria are available to judge the likelihood of the appearance of these instabilities and, in addition, these criteria assume that the various instability modes are independent and uncoupled from one another.

The final difficulty arises from the many types of singularities which can be present in a three-dimensional flow such as regions where the flow is no longer influenced by the initial conditions. Another singularity is the enveloping of streamlines, a condition which is sufficient but not necessary for three-dimensional separation to occur.

Summary

This is an exciting time in the field of turbulent boundary layer research. On the one hand, tremendous strides are being made in the understanding of the laminar/turbulent transition process and methods are evolving for the modeling of turbulent processes which take into account the existence of coherent structures. On the other hand, requirements for even more intensive activity are being generated by aerodynamic design teams who, in the process of designing aircraft and missile systems of ever-increasing complexity, are pushing today's turbulence models far beyond their range of applicability.

Happily, turbulence is one subject in which there appears to be a good connection between the theoreticians, the numerical modelers, and the experimentalists. Important advances in each of these fields made over the past decade in the theory of dynamical systems, direct simulation procedures for the Navier-Stokes equations, and advanced optically based instrumentation systems, give great hope that significant improvements will be made in turbulence modeling over the next few years. The proceedings of this meeting will serve as a valuable guide to those areas in which research is most critically needed and a useful catalog of the most promising analytical, numerical, and experimental methods by which this research can be carried out.

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7/24/87

VON KARMAN INSTITUTE FOR FLUID DYNAMICS

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Von Karman Institute for Fluid Dynamics (VKI), located in Rhode Saint

Genèse, Belgium, was established in 1956 through the leadership of Dr. Theodore von Karman and under the auspices of AGARD. It is incorporated in Belgium as an international research center and functions as an integral part of Belgium's higher education structure. Funding support for the institute (60 percent) comes from contributions from Belgium, the US, France, Germany, and nine other countries.

The total complement of permanent personnel is about 90, of whom 13 are professors and 21 are engineers or technicians. Many of the professors have dual appointments with universities. For example, the director, Professor J.J. Ginoux, also has a position as a professor at the Université Libre de Bruxelles. There are some 50 researchers, in addition, at various postgraduate levels working on projects and theses. The institute has extensive experimental facilities in fluid mechanics which it uses in its research and academic programs.

The Academic Program

The VKI Diploma course is a 5th year program of study in fluid dynamics. The language of instruction is English. Graduates of the Diploma course may continue to work in a 3-year program on a major research project leading to a doctoral thesis which may be presented at a Belgium university or another university abroad. In 1985 there were four graduates of this program, two from the Katholieke Universiteit Leuven and one each from Université Libre de Bruxelles and Vrije Universiteit Brussel. One of the attractive features of this program is the large emphasis on experimental measurements--evident in the titles of the 1985 theses which were:

- An investigation of the 3-D viscous flow field in stationary turbine blades
- Rotating stall in axial flow compressors--experimental and theoretical research
- Experimental and theoretical study of film cooling on a gas turbine blade
- Small-scale study of meandering plume effects on dispersion.

There is an applied research program which is shorter than the 3-year doctoral program; it permits some three to four researchers to work in an advanced level program in applied research in fluid mechanics. Next year's program will include six people, of whom two are from the US. The VKI lecture series on advanced topics in fluid mechanics is quite well known. Ten 1-week lecture series are presented each year with about 500 total attendees. There are also special and short training programs which last from 1 to 3 months.

Research Program

There are three departments in the institute which are (with their directors):

- Environmental and Applied Fluid Mechanics (Professor D. Olivari)
- Aeronautics and Aerospace (Professor J.F. Wendt)
- Turbomachinery (Professor F. Breugelmans).

Environmental and Applied Fluid Dynamics. Professor M.L. Riethmuller, my host, is active in the application of laser Doppler anemometry (LDA) techniques to complex flow fields. (See *ESN* 40-4:145 [1986] for Riethmuller's work in speckle velocimetry). His principal research activities are concerned with mass and diffusion processes in two-phase and internal flows. He has recently measured the linear velocity profile in the viscous sublayer with a view of determining the skin friction (Leprince and Riethmuller, 1986). Measurements close to the wall present many technical difficulties, and this work demonstrated the feasibility of the skin friction study by means of LDA.

Riethmuller is also responsible for the development and application of optical and laser instruments for the institute. Many of the laser velocimeters and laser visualization systems have been developed in-house over a period of 15 years. This development includes not only the optical assemblies but also the electronic processing units. There are eight complete optical systems for LDA measurements including, among others, a complete three-dimensional (3-D) system and two 2-D systems. The laboratory personnel can easily determine coherent structure in complex flows by means of laser sheet techniques (five devices) and they are also working with a fiber optic system. Of the laser sheet devices, one involved a scanning mirror with feedback control that would be especially effective in study of periodic vortex shedding flows. The laboratory has three argon lasers, a q-switched ruby laser, and several helium-neon lasers. A recent addition to the laser equipment is a J.K. pulsed laser of 1 joule for speckle velocimetry research. All in all, this very impressive set of modern measurement devices indicates the emphasis that VKI puts on the development of new measurement techniques in fluid mechanics.

The research projects in the environmental and applied fluid mechanics

department are concerned with six different areas:

- Wind engineering (forces and pressures on buildings, pollutant dispersal, surface vehicle aerodynamics)
- Industrial processes (flow in ducts and components, flow in heat exchangers
- Mass transfer, diffusion processes and two-phase flows (ejector design, heavy gas dispersion)
- Heat transfer--natural and free convection (thermohydraulics in porous media)
- Fundamentals of fluid dynamics solutions of Navier-Stokes equations (vortex dynamics, mechanics of turbulence)
- Laser and digital image analysis applications in fluid dynamics.

I found the effort in fundamental fluid dynamics which has recently involved the development of an implicit Navier-Stokes solver for laminar, incompressible steady-state flows using the approximate factorization method proposed by Beam and Warming particularly interesting. The code is applicable to curvilinear nonorthogonal coordinate systems, and a new way of introducing artificial dissipation has been used in an efficient manner. The code has been tested on a wide variety of internal flows.

Another area of investigation by numerical simulation is concerned with industrial processes involving flow in ducts and gas-particle flows. Modeling of air droplet flows in the inlet of a natural draught cooling tower is a difficult problem. In a recent report Professor C. Benocci has developed a solver (Benocci et al., 1986) which is a coupled solution for the gas and droplets in 2-D and axisymmetric geometries. The code uses finite difference techniques and an eddy viscosity turbulence model which has been modified to take into consideration the droplets. Good agreement is obtained with small-scale test and full-scale measurements. This project is a good example of the industrial work done by VKI.

In the area of pollution dispersal, VKI has a small-scale facility to allow simulation of instantaneous release of heavy gases in a still atmosphere. An isolated chamber equipped with a double floor is extensively instrumented with gas sensors and video and recording equipment. A digital imaging processing (DIP) system (*ESN* 41-5:278-280 [1987]), which has also been used in a study of jet mixing, is available for this project. The DIP may be used directly with video and infrared cameras and includes a Matrom image memory with a PDP 11/34 microcomputer which controls the overall system.

A further test facility, concerned with the postaccident heat removal situation in a nuclear reactor, has been developed to study the thermohydraulics of liquid-saturated and heat-generating porous media. The simulation of the nuclear heat decay in the debris bed is accomplished by dielectric heating. The test facility is being used to develop and test computer models of the temperature history of the bed. Quantitative thermography of the debris bed in addition to visualization is being used in the model development.

The Aeronautics and Aerospace Department. Professor J.F. Wendt, department head and dean of faculty, is an American who received his Ph.D. from Northwestern University. The department is involved in three research areas:

- High-speed aerodynamics (shock/boundary-layer interactions, transonics interference, hypersonic aerothermodynamics, chemical reacting boundary layers)
- Low-speed aerodynamics (boundary layer 3-D transition, turbulence modeling, vortex/strake interaction, 3-D wakes, channel flows)
- High-incidence aerodynamic (strake-wing configurations, vortical flows, and vortex breakdown).

One of Wendt's research areas is high-incidence aerodynamics. His department is involved with the European Space Agency's Hermes project (joint with France) and there is, as in the US, a renewed interest in hypersonics.

Work in shock-wave/boundary-layer interaction is an example of the research conducted by Wendt. This was an experimental investigation of a laminar boundary separation induced by an oblique shock in a flow at Mach 2 in the VKI supersonic tunnel. Flow measurements were made in the detachment bubble to within 0.1 mm of the surface by means of LDA. Comparisons were made of velocity and surface pressure data with computations based on a 2-D Navier-Stokes code developed at VKI. Dr. Grundmann, a recent addition to the staff, would like to extend this experiment and analysis to 3-D shock-induced separation of laminar boundary layers based on the Navier-Stokes equations. This latter work would be applicable to engine intakes, an area in which the department has previously done some work in conjunction with Messerschmitt-Bölkow-Blohm (MBB) and to

the problems that the Tornado had with its intake on weapons firing.

Turbomachinery Department. This department is headed by Professor F.A. Breugelmans. The department's research areas are listed as:

- Turbines (secondary flows, unsteady wake flow, transonic turbines, heat transfer)
- Compressors (nonaxisymmetric flows, rotating stall, analytical studies)
- Pumps (blade-to-blade measurements)
- Diffusers (diffuser optimization inlet and outlet channels, separated flows in cascades).

The previous doctoral work mentioned above was concerned with the turbomachinery area. The department has a low-speed subsonic continuous cascade with room for seven to ten blades. The 2-D flow is maintained by means of side-wall suction which is independent of the main flow. The cross sectional area is 12 cm×50 cm. The high-speed cascade tunnels are blowdown facilities with discharge to atmosphere. In addition, there is a low-speed turbine facility and a turbocharge test facility. All of these facilities have automatic data reduction equipment and connection to the central computer, the VAX 11/780. LDA techniques and hot-wire anemometry are presently being used for measurements in the turbomachinery laboratories. In his current research, Breugelmans would like to develop laser speckle velocimetry as a diagnostic tool, particularly for radial components. In numerical techniques emphasis is on the application of the subdomain approach. The subdomain method permits better definition of local flow problems such as those involving stagnation points and shock wave modeling.

Experimental Facilities. VKI has an extensive set of experimental facilities. As part of its 30th anniversary celebration VKI published *Facilities and Instrumentation*, (1986), a brochure which outlines in detail the 28 experimental devices available to researchers and students. There are six low-speed wind tunnels, most of which are used in training of students in experimental techniques; for example, one is used in the study of aircraft wakes and 3-D velocity measurements. There are facilities available for environmental studies and atmospheric wind simulation for tests on ground structures. A recent tunnel improvement is a moving belt to better simulate the ground effect on a moving vehicle. This automobile aerodynamics tunnel is 2 m×3 m with a length of 20 m, is equipped with a six-component floor balance, and has facilities for boundary layer suction. There is also a reasonably sophisticated supersonic/transonic wind tunnel which has been used to study shock/boundary-layer interactions. In the area of hypersonic flow VIK has a blowdown facility with a capability of Mach six and a long shot-free piston tunnel with a capability of Mach 15 to 20.

Conclusions

I was quite impressed with the level of the research effort and of the staff of VKI. There is a healthy emphasis on an experimental approach to problem solving backed by a firm theoretical effort. I think also that the lecture series and short courses run by VKI help the staff to remain current in their field. In this past academic year there have been three lecture series in turbomachinery:

- Flow in Centrifugal Compressors
- Small High-Pressure Turbines
- Finite Element Calculations Methods and Their Application to Turbomachinery Flow.

There have been two lectures series on computational physic and two on turbulent structure and modeling. When a new technique appears, VKI invariably conducts a lecture series which involves the relevant specialists in Europe, the US, or Japan.

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7/02/87

Ocean Sciences

THE MARGINAL ICE ZONE EXPERIMENT: MIZEX-87

by Donald R. Johnson and Jeffrey D. Hawkins. Both authors are oceanographers in the Remote Sensing Branch, Code 321, Naval Ocean Research and Development Activity, NSTL, Mississippi.

Background

The marginal ice zone (MIZ) occurs geographically as a transition area between pack ice and the open ocean. Physically, it is an area of dynamic interaction involving ice, ocean, and atmosphere. In a very real sense, the location of the MIZ is determined by the competing forces of ice advection from poleward, warm-water advection from equatorward, turbulent breakdown from ocean wave and mesoscale eddy grinding, and from *in situ* ice formation and melt. In response to this complex forcing, the ice edge moves seasonally, and interannually, hundreds of kilometers equatorward or poleward, covering or uncovering thousands of square kilometers of water surface. Regional climates for high latitude countries depend on the results of this competition. Similarly, global climates are determined to a great extent by the amount of open water available for moisture input into the atmosphere, for heat exchange with the atmosphere and, with increasing importance, for ocean absorption of carbon dioxide.

The Marginal Ice Zone Experiment (MIZEX) began with a pilot summer field program in June and July of 1983. This program was subsequently expanded into a full summer program in May-June 1984 (see MIZEX Group [1986] for a complete account). MIZEX-84 was a coordinated international program using the resources and expertise of 11 nations, with seven ships, eight remote-sensing/meteorological aircraft, and four helicopters supporting a broad range of investigations focused on physical and biological processes in the MIZ. O.M. Johannessen of the Nansen Remote Sensing Center (Bergen, Norway) and D.A. Horn of the Office of Naval Research/Massachusetts Institute of Technology served as principal coordinators. The Fram Strait region between Svalbard and Greenland was selected for field work since it is through this area that the principal outflow from the Arctic Basin meets relatively warm North Atlantic water, creating the dynamic interactions of interest.

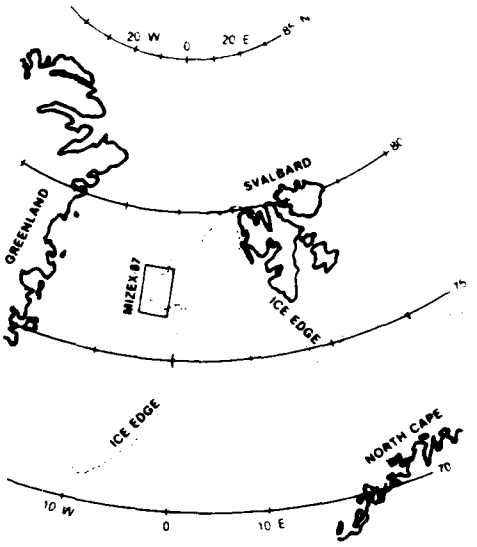

Figure 1. Location of the MIZEX-87 field experiment during March and April 1987. An ice edge analysis for the 24th of March 1987, is superimposed.

In March and April 1987 the first winter MIZEX was conducted, again in the Fram Strait region (Figure 1). Although the overall objectives were the same as in the summer experiment, winter conditions produce dramatically different dynamic balances and different interactions between ice-ocean conditions and their remotely sensed electromagnetic radiation properties. The primary goals of the 1987 field program (MIZEX BULLETIN, 1986) were to:

- Exercise and verify the remote-sensing capabilities for real-time detection and tracking of ice-ocean eddies in winter
- Provide the first comprehensive data set on the oceanography of the winter MIZ vital for ocean and acoustic modeling
- Provide the first data on important meteorological questions, including cyclogenesis and surface atmospheric boundary conditions in the winter MIZ
- Provide a unique data set on ice and surface gravity wave interaction in winter
- Provide ambient noise data.

Taking advantage of the ongoing MIZEX effort, the Remote Sensing and the Polar Oceanography Branches of the Naval Ocean Research and Development Activity (NORDA) participated in MIZEX-87 with an adjacent (in both location and time)

study directed toward understanding microwave signatures over ice. This subproject has been called BAJA MIZEX.

BAJA MIZEX

BAJA MIZEX expands on the main MIZEX program with an ice product applications research effort focusing on the currently flying GEOSAT altimeter during its exact repeat mission (ERM). By taking advantage of equipment and personnel on site for the main program, it was expected to accomplish a relatively low-cost, but high-return experiment with both immediate and long-range applications value.

GEOSAT flys to 72 degrees latitude. This places its ground tracks several hundreds of kilometers to the south of the MIZEX-87 operational area. However, at this latitude, the ground tracks converge in such a manner that several tracks per day pass over an area easily covered by aircraft (Figure 2). In addition to increased satellite altimetry coverage at this latitude, the BAJA MIZEX effort allowed a larger scale examination of the ice edge and its related oceanographic features in the Greenland Sea during aircraft transitions between this area and the northern MIZEX area.

Ice index maps from the GEOSAT altimeter are currently being distributed as operational products. Global charts of ice edge are created from the combination of this product together with ice edge determinations from other sources such as the scanning multifrequency microwave radiometer (SMMR) and the advanced very high resolution radiometer (AVHRR) and the operational line scanner (OLS). Figure 2 shows an example of a portion of the ice index product from the area in which BAJA MIZEX has been conducted.

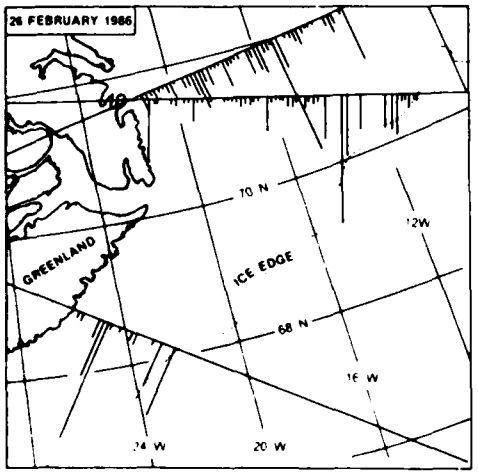

Figure 2. Three GEOSAT ground tracks for 26 February 1986 are shown, with the ice index represented as lines perpendicular to the tracks. For comparison, ice edge as determined from AVHRR is also shown. The ice index appears to give a good representation of the presence of sea ice. The strong variability of the ice index across the ice is one of the subjects of this study and may lead to additional characterization of sea ice and its distribution.

The GEOSAT ice index is formed from the strength and shape of the returned radar altimeter pulse. Smooth sea ice tends to act as a specular reflector of radar energy, with the principal return occurring at incident angles very near nadir. At off-nadir angles, the return diminishes rapidly. This creates a pulse signature with a strong spike at the leading edge and a near-exponential decrease in the trailing return. In contrast, open ocean water tends to be rougher at scales which scatter radar energy in all directions. As a result, the returned pulse is broader, with more energy in the trailing return. The ice index is formed by first flagging the presence of ice with a critical value in a late gate of the trailing return, and then quantifying the index with a ratio of signal strength to the late gate.

The algorithm for producing the ice index (Dwyer and Godin [1980]) was formulated for the GEOS-3 altimeter and carried over to GEOSAT with some modification to accommodate the differences between methods of sampling the returned pulse (Lybanon, 1986). As an indicator of the presence or absence of sea ice, it seems to be accurate and reliable when compared to AVHRR and visible satellite images. However, no "ground truth" has been available to validate the index and, more importantly, no dedicated effort has previously been made to examine the full potential of the widely varying ice index inside the ice edge. It is the rich variability of the ice index that we wished to investigate and, eventually, to exploit in creating future ice products. The all-weather capability of radar altimeters along with their relatively high resolution (2-7 km) make them important and useful instruments for investigations of sea ice.

Several other factors have been involved in making BAJA MIZEX an attractive experiment. One of these factors concerns the opportunity of beginning collaboration between ERS-1 (ESA Remote Sensing Satellite) and NROSS (Navy Remote Ocean Sensing System) principal investigators in experiments which are likely to lead to validation exercises for these two planned series of satellites. GEOSAT is currently serving both sides to test technologies for the next generation of oceanographic satellites. In this simple

manner, meaningful satellite intercalibration, together with exchanges of data and expertise can be made possible. For this prospect, it is anticipated that MIZEX-87 will lead to validation experiments in 1991.

A second factor governing the formation of BAJA MIZEX concerned the availability of synthetic aperture radar (SAR) aircraft together with passive microwave aircraft. With respect to the SAR priorities, we had hoped to focus both active (altimeter and SAR) and passive microwave sensors on the same over-ice pass as a first step in providing quantitative descriptions of the backscatter process as a function of ice type, age, and properties. BAJA MIZEX provided a forum for similar comparisons among several distinctive types of remote sensors.

In addition to the MIZEX-87 objectives listed above, then, the further objectives for BAJA MIZEX were to:

- Begin collaborative work among ERS-1 and N-ROSS principal investigators on programs leading to the validation of these two series of satellites
- Develop ice distribution, type, and property products for satellite altimeter data
- Develop a comparative description of synthetic aperture radar (SAR) and passive microwave imagery as a function of ice distribution, type, and properties.

Field Program

The ocean research platforms for MIZEX-87 consisted of the ice-strengthed Norwegian ship M/V *Polar Circle* with catered helicopter service, and two open-ocean research ships: M/V *Haakon Mosby*, University of Bergen, and RV *Valdivia*, University of Hamburg. Remote sensing aircraft participants included the Intera SAR (Star System), NORDA's K-Band Microwave Radiometer System (KRMS), and a Naval Research Laboratory (NRL) P-3 carrying a passive microwave imager and laser profilometer. Satellite sensors included NASA's SMMR and the HVHRR. In addition, a Norwegian P-3 provided synoptic aerial coverage with air-deployable, expendable bathythermographs (AXBT's) and sonobuoys. To coordinate the activities in an efficient manner a center was established in Tromso, Norway, for overall activities, and an office established in Svalbard for SAR flight coordination. Weather forecasting and basin area ice edge determinations from satellite were made at the Tromso center and relayed to the field parties.

The KRMS is a microwave imager that operates at a center frequency of 33.6 GHz. At a flight altitude of 3000 m, the cross-track coverage is 7.25 km at a resolution of 36 m. This particular frequency falls within an optimum band for uniquely characterizing open water, first-year ice and old ice based on brightness temperature measurements. The NRL P-3 carried a 90-GHz passive microwave scanner, a laser profilometer, and a 70-mm camera.

The SAR system is commercially available from Intera of Canada. It is an X-Band, HH polarization system with either 25-km or 50-km ground swath at 6-m to 12-m resolution. Recording was done in three modes: onboard real-time display on dry silver paper, onboard digital recording of image data, and image link to ground receiver.

Field activity began on 15 March 1987 with the *Valdivia* occupying stations in the Greenland Sea; on 22 March, *Polar Circle* and *Haakon Mosby* sailed for the ice edge in the Fram Straits. While the ships were in transit, the KRMS aircraft began underflights along GEOSAT tracks, passing over approximately 2000 km of collocated ground tracks on 23, 24, and 26 of March. The schedule had called for the SAR aircraft to fly coincidentally with the KRMS on 23 and 24 March; however, an unfortunate breakdown in the SAR aircraft prevented its coincident participation. As an alternative, the SAR was flown along GEOSAT ground tracks at the end of MIZEX on 13/14 April.

Arriving in the main MIZEX area on 28 March, the SAR aircraft provided a central and unique contribution to the experimental program. The SAR mapped a 240×300-km area centered on the *Polar Circle* in real time on a daily basis until 10 April, and transmitted the earth-located, geometrically rectified SAR images directly to the ship. Scientists onboard interpreted the images and selected specific sites for ground-truth observations. Areas of new ice, first-year ice and multiyear ice of various stages of deformation were located and targeted for examination along with eddies on the ice edge and within the MIZ.

When specific ice targets were chosen, the *Polar Circle* moored to the selected floe and scatterometer/radiometer measurements were made from the ship's rail. In addition, a landing party obtained direct physical characteristics from the floe. For targets not easily accessed by the *Polar Circle*, the helicopter was deployed to make microwave measurements as well as to obtain aerial photography.

Mesoscale eddy locations, as identified in the SAR images, were transmitted to the *Haakon Mosby* and *Valdivia* for intensive examination with CTD's, acoustic Doppler current profilers, and strings of

floe-suspended Aanderaa current meters. ARGOS transmitters monitored the location of instrumented floes. Along with the oceanographic and ice observations, an intense program of meteorology from all ships measured both the microscale boundary characteristics as well as the mesoscale patterns. Biological sampling at the ice edge was conducted in order to examine the responses of phytoplankton to the onset of light and the effect of early growth on zooplankton reproduction.

Future

For the next step in ice edge investigations, a program called SIZEX, Seasonal Ice Zone Experiment, has been proposed by the Norwegian, French, Canadian, and US participants to the European Space Agency to be conducted in 1989 (pilot) and 1991. The overall objectives are to perform ERS-1-type sensor signature studies for ice discrimination and to meld ERS-1 retrievals with mesoscale-coupled ice-ocean models for ice forecasting. This work is expected to involve the Barents Sea, Fram Strait, and Greenland Sea areas. Planning for this study will continue with a meeting this coming summer.

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6/16/87

THE OCEANOGRAPHY SESSION OF THE EUROPEAN REMOTE SENSING MEETING

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.

The European Association of Remote Sensing Laboratories (EARSeL) held its annual general assembly and symposium at the Leeuwenhorst Congress Centre in Noordwijkerhout, the Netherlands, from 4 through 8 May 1987. About 150 people, representing 18 different countries, participated in six concurrent workshops: renewable resources, nonrenewable resources, political implications of remote sensing, meteorology, cartography, hydrology and snow, and oceanography and sea ice. There are no formal abstracts available, but the presented papers will be published in a special issue of the *International Journal of Remote Sensing*. Since I only attended the oceanography session, which was organized and chaired by T. Allan, Deacon Oceanographic Laboratory (DOL), UK, that is the only one reported here.

Wind and Waves

A comparison of wave parameters determined from Side Looking Airborne Radar (SLAR) images and a pitch-roll buoy by P. Hoogeboom, Royal Netherlands Oceanographic Institute (TNO), opened the session. The buoy, a Boug-Wavec type was located about 10 miles off the Dutch coast, and an attempt was made to compare the directional wave spectrum and directional spreading measured by both *in situ* and remote sensing methods. Some differences were expected because the nature of the data recorded differs markedly. The radar records a spatial data set at one instant in time, while the buoy records a time series at a singular location. Both data sets were made similar by processing techniques, but some differences remained. The low-frequency waves were present in the SLAR data but absent in the Wavec series. In addition, wave height is a problem with SLAR, since wind variations may be confused with swell components.

P. Challenor (DOL) presented a review of the progress that has been made in wave measurement from satellites since the launch of GOES-3. He discussed both altimeter and SAR data, and indicated that there is still a great deal to be learned. Of the two, it appears that altimeter data are better understood in the sense that the relation between the EM signal and the hydrodynamic effect is better known. Although it is possible to obtain certain wave parameters under specific conditions, many problems remain. There is a lack of "sea truth" data and we need to know what is being measured before the results can be properly interpreted. Because of this, more work has

been done in attempting to understand the data than in exploiting it. Challenor believes that, as yet, remote sensing has not really contributed anything to wave research!

Another problem associated with SAR systems, relating to data quality, was introduced by J. Baker, National Remote Sensing Centre (NRSC), UK. To minimize smearing of data produced by platform acceleration, a small data integration time is required, but to minimize smear due to platform velocity a small altitude to linear-speed ratio is required. In practice, this means making the satellite altitude as small as possible. Satellite SAR has the potential to obtain the global wave spectrum, but it would appear that this potential can be reached only if the platform is at an altitude less than 300 km (typical of shuttle operation), rather than the 800-km altitude typical of satellites. For this reason, Baker wonders whether real aperture radar (RAR) might not be a more suitable approach than SAR systems.

The possibility and extent of future wave studies using remote sensing techniques was discussed by D. Carter (DOL) and M. Strokosz (NRSC). They considered both narrow swath and conically scanning altimeters, along with SAR. In all cases the key to successful utilization of these data is a knowledge of the relationship between the real sea surface and the EM signal. With this knowledge it is possible to study the temporal and spatial variability of the wave field on a global scale, in addition to the joint distribution of parameters and wave spectra. This information is needed in deep water for ship routing wave forecasts, climate statistics, model validation, initial wave conditions for models, wind field determinations, and hindcast model results. In coastal waters site-specific data are usually required, which are better obtained from buoys or HF radar installations.

R. Frassetto, Istituto per lo Studio della Dinamica delle Grandi Masse, Italy, described some experiments directed toward the feasibility of using ERS-1 data in coastal and inland waters. These involved comparison of the wind vector derived from scatterometer data with *in situ* measurements. He found that grid size must be smaller than 50 km, and that the scatterometer algorithm varies from site to site. Frassetto believes that he has demonstrated that the scatterometer-derived wind vector can describe the real world in coastal areas quite well as long as the scatterometer is calibrated for each area and different site-specific algorithms are used.

Ocean Topography

The height variability in sea-surface as measured by satellite altimetry was discussed by P. Woodworth, Proudman Oceanographic Laboratory (POL), UK. From time averages of GEOSAT altimeter data, the geoid is known to an accuracy of about 1 m, so it is now possible to sample mesoscale variability of surface currents. This capability should improve as the radial orbit error is parameterized as more altimeter data becomes available. Since viable algorithms are available and large groups are not required for data analyses of this type, small research teams can make a significant contribution.

Problems faced by modelers desiring to use altimeter data were addressed by J. Minster of the Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER). Questions having to do with the transfer from large to small scale and the transfer from surface parameters to those in the water column are most troublesome at this time. Apparently answers do exist, but the variability signal and error spectra must be better understood. In addition, it appears that results will be maximized only when other data are used in conjunction with the altimeter. As a follow-on to this, K.F. Wakker and his group from Delft University of Technology, the Netherlands, surveyed some altimeter data processing techniques. They briefly described some corrections that have to be applied to altimeter measurements, identifying the geoid model and satellite orbit as the major error sources when the data are used to determine ocean topography. They also described the classical techniques of applying colinear tracks and crossover difference minimization to detect sea-surface mesoscale variability and model the mean sea surface.

According to D. Webb (POL), the prime objective for ocean topography studies in the near future must be the measurement of both the mean sea surface and the geoid to an accuracy of a few centimeters. This requires advances in many fields, including reducing the errors in the wave bias and ionospheric corrections, improving satellite tracking and altimeter design, and achieving milligal accuracy gravity measurements. Only when these objectives have been achieved will it be possible to use satellite measurements to their fullest extent in the study of both the earth's deep structure and global ocean surface currents. Webb cautioned that satellite measurements are only of the oceanic surface skin, so there is a need to complement the satellite studies with an international program of subsurface oceanic measurements.

Ocean Color

A method using false-color aerial photography was developed recently by C. Meulstee and his colleagues at Rijkswaterstaat, the Netherlands, to quantitatively assess the biomass of macrophytes growing on intertidal mudflats. This method is based upon a direct relation between color densities and field biomass determined at a number of sample plots, and it includes the necessary radiometric corrections. Interestingly enough, it appears that the bidirectional reflectance properties of the macrophytes play a minor role in the relation between color density and biomass, probably due to the flat character of the intertidal area and the small thickness of the macrophyte layer.

Implications for the interpretation of remotely sensed ocean color in terms of *in situ* measurements were discussed in some detail by J. Aiken, Institute for Marine Environmental Research, UK. The standard algorithms relating water reflectance at blue and green wavelengths to chlorophyll concentration or the diffuse light attenuation coefficient (K) turn out to coincide almost exactly with the theoretical values if it is assumed that chlorophyll-like pigments are the only ones having a significant influence on ocean color. On the other hand, these algorithms are unrepresentative of particular oceanic areas dominated by plankton blooms of species having accessory pigments which absorb green light, such as the highly productive temperate and subpolar regions. Aiken presented data from selected locations, which included not only optical measurements but also pigment analyses and plankton identifications, to substantiate these statements.

Along the same line as the previous speaker, S. Boxall, Southampton University, UK, addressed some other limitations to the use of remotely sensed ocean color data. One of the major problems in interpreting these data is involved with the determination of the proper atmospheric correction. One approach is to assume that the ocean surface is "black" at 670 nm. This works fine in the open ocean, but such an assumption introduces a significant error in coastal areas where suspended sediments contribute sizably to the reflected signal. The other approach involves the development of empirical algorithms (usually site specific) to account for atmospheric scattering. The result has been that the coastal zone color scanner (CZCS) has worked everywhere except in the coastal zone. The situation shows no immediate sign of improvement either, as both SPOT and TM sensors repeat track only every 18 days and they give very few usable scenes over European coastal waters. Thus, secondary products such as K and chlorophyll concentration have all been calculated with clear-ocean techniques, so that the original objectives of CZCS have not been met.

With this negative note, it was up to D. Spitzer, Rijkswaterstaat, the Netherlands, to end the session on ocean color with a positive note. It was difficult to do this in light of the data available at the present time. He noted that since climatological, ecological, and biochemical aspects play an increasing role in coastal waters management and global flux studies, application of optical remote sensing techniques will become more and more important with the passage of time. Nevertheless, there are no optical satellite instruments even being planned for the 1980's capable of discriminating oceanic constituents. Although both SPOT and the Japanese MOS satellite have multispectral color sensors, both are wide band and have center wavelengths that are not optimal for ocean studies. The most promising ocean color mission that is being planned is the polar platform of the space station (Columbus Project) and possibly the US Ocean Color Imager (OCI) both scheduled for launch in the late 1990's.

Sea-Surface Temperature (SST)

This session was begun by P. Le Borgne describing the current work of his group at Centre de Météorologie, France, concerned with interpretation of radiometer data from the METEOSAT and NOAA-9 satellites. They combine data sets from both satellites to produce SST fields, and they also have developed routines to generate solar irradiance fields and survey phytoplankton blooms using visible Advanced Very High Resolution Radiometer (AVHRR) data. Using the solar irradiance fields, the group hopes to retrieve small-scale characteristics of the oceanic atmosphere thermodynamics.

A tutorial paper on the general subject of sea-surface temperature measurements using remote sensing techniques by D. Llewellyn-Jones, Rutherford-Appleton Laboratories, UK, completed the SST session. Emphasis was given to a comparison of requirements of the oceanographic community to the specifications of the sensors planned to be in orbit within the next decade. At the present time the AVHRR sensor is capable of giving accuracies of ±0.6°C in a cloud-free atmosphere, while the scanning multi-channel microwave radiometer (SMMR) sensor will deliver all-weather accuracies of ±0.7 to 1.5°C. In order to measure heat fluxes on the order of magnitude of 10 W/km^2, necessary for climate research,

Table 1

Performance of Various Ice Sensors

	Parameter	Operable Sensor	Comment
Sea Ice	Concentration	PMR, SAR, RA	
	Edge location	PMR, RA	
	Ice type	PMR, SAR	
	Motion	SAR	
	Roughness	RA, LIDAR, SAR	Marginal performance
	Wave propagation	SAR	Marginal performance
	Snow cover	SAR, PMR	Marginal performance
	Thickness	?	No adequate sensor available
Land Ice	Elevation	RA	
	Surface features	SAR, TM	Marginal performance
	Surface temperature	TIR, PMR	Marginal performance
	Accumulation rate	TIR, PMR	Marginal performance
	Surface velocity	RA, LIDAR, SAR, TM	Marginal performance

precision better than ±0.3°C is required. In addition, daily, global coverage is a desire of many investigators, and spatial resolution of less than 1 km is needed for coastal monitoring and medium- and small-scale oceanography. It appears that the resolution and coverage problems will not be soon solved, but the precision of the ERS-1 ATSR sensor and other sensors to follow is expected to be ±0.3 to 0.5°C.

One problem raised by Llewellyn-Jones that has not been adequately addressed in the past is that of skin vs. bulk temperature. Depending on the amount of turbulence present in the surface layer, the bulk temperature may be as much as 0.5°C higher than the skin temperature. With this discrepancy greater than the planned precision of forthcoming sensors, it seems imperative that the bulk-skin temperature difference be measured and included in SST models. It was suggested that in the future all *in situ* temperature measurements include both bulk and skin values.

Ice

The present state of the art in the measurement of sea and land ice parameters using remote sensing techniques was independently covered by P. Gudmandsen, Technical University of Denmark, and W. Rees, Scott Polar Research Institute, UK. The following sensors, with their appropriate acronyms, were discussed: scanning multichannel microwave radiometer (SMMR); passive microwave radiometer (PMR); side-looking airborne radar (SLAR); synthetic aperture radar (SAR); radar altimeter (RA); laser light detecting and ranging (LIDAR); thematic mapper (TM); and thermal infrared (TIR), along with visible sightings (V). The type of ice, determined by shape, texture, pattern, and reflectivity is discernible using V, PMR, SLAR, and SAR. Ice concentration, which requires discrimination between water and ice, may be determined by using V, PMR, SAR, and SLAR. It is possible to differentiate between ice and clouds by using SAR or SLAR. Ice movement, on the other hand requires consecutive coverage over an extended period of time along with some ground (fixed) reference points. Since visible and IR sensors are affected by clouds, and clouds are a constant fact of life in polar regions, both authors indicated the need for a multisensor approach in this part of the world, including both visible and microwave elements.

Although land ice and sea ice cover about the same area (land ice 16,000,000 km^2; sea ice 25,000,000 km^2), they are different in many other respects, especially thickness, with land ice averaging about 2 km in thickness and sea ice averaging 10 m. Rees utilized a table showing what sensors could be employed in the determination of various ice parameters, which is summarized in Table 1. As may be seen, there appears to be some room for improvement.

Conclusion

This meeting of European remote sensing workers was not very well attended by the oceanographic community. There were only about 30 people present for the oceanography session. However, the people who did attend included some of the most active and well known in the business. The chairman of the session, Tom Allan, deserves a lot of credit for putting together an outstanding meeting. The research programs presented and the analysis of programs past, present, and future

discussed at this meeting all exhibited careful and sometimes bold thought. It appears to me that a number of European investigators are doing excellent work in this field, but that this group of leaders in remote sensing work is a relatively small one. I see much of the same group at each meeting I attend, and what I do not see is any significant number of graduate students presenting papers. They are present in other fields of marine science, but not remote sensing. Whether this is due to the fact that there are no European graduate students in remote sensing, or they just do not attend meetings, is not clear at this point.

6/10/87

Physics

BASIC RESEARCH IN OPTOELECTRONICS, OPTICS, AND LASER SCIENCE AT BERLIN

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1988.

West Berlin is not only a courageous and rather grim stronghold at the limits of the Western World, but also a strong citadel of learning. This is not only because of tradition, but also because the federal government of West Germany, at least until recently, pursued a deliberate policy (accentuated by economic advantages) of building up the beleaguered city's technical and scientific resources.

On a visit in March to West Berlin, I looked into the basic research done by academics in the area of optics, optoelectronics, and laser development. I found that most of the work is conducted at the Technical University and at the Heinrich Hertz Institute. This will be a brief review of the most important research lines I became aware of at these two institutions, and I ignore other, probably equally good work done at the Free University and at the Hahn-Meitner Institute.

Research at the Technical University

The bulk of work at the Technical University is done in three departments (called, according to German tradition, "Institutes"): the Institute of Optics, the Institute for Solid State Physics, and the Institute for Radiation and Nuclear Physics. These are all within the School of Physics. Additional related work is carried out at the Schools of Physical and Applied Chemistry, of Physical Engineering, of Process Technology, of Transportation, of Electrical Engineering, and others. I find it profitable to report the work I saw in the School of Physics by organizing the material according to its location at the three institutes where I spent most of my time.

Institute of Optics. This department is directed by Professor Dr. H.J. Eichler. At the moment, major reorganization and large-scale building activity is going on, so that data about the current size of the optics institute may not be quite relevant. In any case, the permanent total scientific staff consists of about 20 scientists and a small number of graduate students. The major subareas of research are:

- New development work on Nd:YAG lasers
- Development of longitudinally discharge-excited excimer lasers
- Production and characterization of thin metallic and dielectric layers for mirrors, photodectors, and optically bistable switching elements
- Excitation- and relaxation-processes in materials relative to optical bistability and phase conjugation processes
- Time-resolved fluorescence and UV-absorption spectroscopy
- Interferometric and laser spectroscopy studies
- Development of metal vapor lasers
- Time-resolved electron spectroscopy for the study of laser-induced phase transitions.

In addition, Eichler is currently involved in the organization of a semi-private "Laserinstitute" that would involve industrial participants and will concentrate strongly on the scientific basis of industrial laser applications.

Solid State Lasers. Eichler is convinced that, contrary to common belief, there is still much basic research that can and should be done in the area of Nd:YAG lasers. New pumping methodologies, improving of beam quality, achievement of higher efficiency, convenient direct production of 20-ps pulses, compact designs for up to 1-kW power output, modulation, and the further development of portable, battery-operated YAG lasers are points in case. For example, a new chair is now being established (with EUREKA support) to develop commercially marketable 1-kW Nd:YAG lasers for industrial applications.

I mention two developments, particularly dear to Eichler. One was the achieving of 700-ps mode-locked pulse operation (with spikes 10 μs wide and repetition rate of 46 μs), done by detuned acousto-optical pulse-energy-modulation of a 1.32-μm Nd:YAG laser. The other, related research, concerned Q-switching of a CW mode-locked Nd:YAG laser, also achieved by frequency detuning, and yielding pulse widths less than 200 ps.

Excimer lasers. The institute's major concern in this area is the development of small, yet efficient, high-beam-quality ultraviolet noble gas-halide lasers with acceptable output power. The crux of this research has resulted, so far, in the construction of KrF and XeF lasers with longitudinal discharge excitation. This was achieved by capacitive high-voltage pulse-excitation, using a foil outer electrode along the narrow laser tube. The exciting pulses employed 80 kV to 100 kV voltages. In one typical experiment, 200 mJ pulsed output, with 10-mW average power and excellent mode-control, was observed at 250 nm.

Copper Ion Vapor Lasers. Eichler is very proud of this work, the crux of which is the use of helical hollow-cathode discharges. Water-cooled copper coils serve as hollow cathodes in a buffer gas mixture of noble gases; the anodes are flat metal walls along the tubes. If sufficiently high current is achieved, the plasma inside the hollow cathode produces, by sputtering from the helical tube itself, the Cu^{++} ions. Several sections of helical cathode/metal wall arrangements can be combined in series. Surprisingly, it is possible to use the same device both for ultraviolet and for infrared operation. Selection is achieved by using different gas mixtures (leading to transfer-excitations of different copper ion levels), and with the use of mirrors with different reflection properties.

Optical Multistability. Eichler told me of a new, purely West German project, aimed at preparing the scientific basis of future optical computing. This project is completly independent of the well-known EJOB European cooperation, and, Eichler says, has "more money in it" than the all-European effort. Participants are Eichler's Optics Institute, the H. Hertz Institute (which is the leader and coordinator), the University of Braunschweig, the University of Duisburg, and the Technical University of Munich. The H. Hertz institute has seven professional scientists on this venture; the other institutions two or three people, each.

So far, the Eichler institute's major contribution in this area was the observation and study of optical multistability in silicon, observed with a CW-operating Nd:YAG laser at 1.06 μm. Creation of an electron-hole plasma leads to refractive index change. Crystals of 500-μm thickness were used, placed in a tuned optical cavity. Steplike multistable behavior was seen at six (or more) increasing power levels.

More recently, the institute began the study of CdS film bistable devices; the novelty here is that, on both sides of the deposited CdS film, an additional semireflecting mirror surface is also deposited. Large areas can be produced in this manner. Although somewhat reluctant to give details, Eichler implied that this bistable device is a possible breakthrough in parallel optical switching.

Study of Phase Transformations. Professor Dr. O. Bestanjoglo, in Eichler's institute, showed me an innovative methodology with which he studies the fast dynamics of melting-thermal diffusion-recrystallization of films made from Si, Ge, GeTe, and other materials. The phase transformation is induced by illuminating with a nano- or picosecond pulse from a Nd:YAG laser; this is introduced into a modified electron microscope, and made to propagate coaxially with the e-beam; the two beams hit the sample simultaneously, and the electron microscopy serves to follow the fast changes in the sample layer. Essentially, one has here a novel form of time-resolved electron spectroscopy.

Institute of Solid-State Physics. This large, 100-people-strong department is led, most energetically and persuasively, by Professor Dr. D. Bimberg. Unlike what I found at the Optical Institute, here was a very large number of students forming part of the research staff (including also 42 undergraduates).

Bimberg says that the essence of his department's work can be characterized as interface studies. The official breakdown of major research areas is as follows:

- Characterization of III-V and II-VI compounds, as well as of Si, with structural, chemical, optical, and electrical methods, including ultralow temperatures, picosecond methods, and high magnetic fields. (Apparently, this institute has the biggest split-coil superconducting magnet in Europe, producing 150-kG fields, equivalent to an 18-T solenoid output.)
- Research on microstructures and optoelectronic devices, including lasers and solar cells.

- Materials-growth and ion implantation.
- One- and zero-dimensional device fabrication and studies on these systems.

Following are the special fields, briefly described, in which Bimberg personally has a hand.

Superlattices and Interfaces. Optical, electronic, and hot electron effects are studied in GaAs/AlGaAs, InGaAs(P)/InP, InGaAs/AlInAs, and even in the very difficult GaAs/Si systems. Scanning cathodluminescence, photoluminescence, calorimetric absorption spectroscopy, and electron-beam-induced spectroscopy were used to further these studies.

Transition Metals in III-V Compounds. Energy levels, diffusion coefficients, thermodynamic stability are here the major concerns. Typical systems under investigation are InP, GaAs, InGaAs doped with Fe, Ti, V, W, Nb, and Mo. Major methods of investigation include photoluminescence, calorimetric absorption spectroscopy, and annealing studies.

Picosecond Semiconductor Lasers and Fast Detectors. Circuit design is probably the greatest success in this area. Gain modulation of unbiased semiconductor lasers, leading to ultrashort (125 ps) light pulses (at repetition rates up to 10 MHz) were achieved in the 0.8- to 1.3-μm range. The central element in the design was the development of a special double avalanche generator, producing large injection-current pulses. One of the lasers with which these experiments were carried out, was a GaAs multi-quantum-well device. But direct gain modulation was investigated also with double-heterostructure GaAs and InGaAsP systems, and with distributed feedback lasers.

Atomic Scale Images of Monolayer Islands at Interfaces. This research, to be published in the near future, allowed for the obtaining of direct images of growth-islands differing by only 2.8 Å (i.e., one monolayer) height at GaAs/AlGaAs hetero-interfaces, and of the columnar structure of quantum wells. It is, I think, a true worldwide "first." Apparently, the techniques employed are a viable optical alternative to the much admired scanning tunnelling microscopy (STM), and the multicolor "pictures" produced under fully computerized control are almost as stunning as those obtained by STM methods. The surface under study is scanned by a sharply focused electron beam, which causes excitations in the molecules. The measurement is then done with a sophisticated use of the analysis of the resulting luminescence and absorption-spectra lineshapes. This approach was made possible by a detailed theory of line shapes, relevant at interfaces. The importance of this work, as Bimberg proudly pointed out to me, is that it allows for high-precision study of growth kinetics in MBE processes and will thus ultimately permit the practical growth of structures with ultrasmooth interfaces only one atomic layer thick.

Institute for Radiation and Nuclear Physics. Because of the deemphasizing of classical nuclear physics research, this institute is building up a new profile. Its director is Professor Dr. R. Buka. Some of the research areas include the following:

- Laser spectroscopy of atoms and molecules
- Time-resolved spectroscopy for laser-induced resonance-fluorescence
- Development of high-power dye laser amplifiers
- Study of highly excited states with combined collision- and laser-excitation.

Here are two interesting experiments that caught my eye:

CW Dye Laser Injection-locking and Frequency Doubling. A small group of young researchers obtained high-power single-mode operation of a CW ring dye laser. This was done by injecting CW single-mode radiation. The intracavity radiation power of this system was then used to generate tunable single-mode UV radiation by frequency doubling in a temperature phase-matched ADA or $LiIO_3$ crystal. This was placed in a ring resonator arrangement. So far, 45-W intracavity fundamental power and over 70-mW extracted tunable UV power has been observed. It is thought that by careful refinements a much better result will be achieved in the near future.

Energy Levels of van der Waals Molecules. Highly excited states of many molecules, including NaAr*, were investigated by a methodology where first a molecular beam was produced through a 50-μm valve. The fast expansion of the gas mixture then cooled it down to a few Kelvins and reduced the density to eliminate collisions. This led to bound alkali-noble gas molecules. At this crucial point, the beam was cross-illuminated by the light from tunable and highly stabilized dye lasers. Both visible and IR beams were used (for other experiments, UV light will be employed too). The absorption spectrum was then carefully observed, leading to the determination of the discrete boundstate levels. In turn, this allowed the calculation of the interaction potential.

Research at the Heinrich Hertz Institute

Even though the origins of this establishment go back to 1928 (when it was

an institute "for the study of vibration science," including radio transmission), it obtained its present status as a governmental research laboratory for communication technology only in 1974. At that time, it became an "incorporated company," owned 50 percent by the Federal Government of West Germany and 50 percent by the State (Land) of Berlin. It is now a leading government institution, employing over 260 people, of which 210 are scientific researchers. The annual budget is around $18 million; of this $11 million were fixed federal and state appropriations; the rest came as "project support" from the Federal Ministry of Research and Technology and from the West German Federal Post Office. Additional project funds (for tasks lasting, on average, 2-3 years) came from industry, and there are also strong ties with the nearby Technical University of Berlin, consisting mainly of shared positions and some visiting scientists and research students.

The official research profile of this institute is focused on broadband electro-optical communications--both on the foundation of a universal German network and of local area networks. While technology transfer plays an important role, the main emphasis is on forward looking, very long-term work. The research is done in two divisions: Communication Systems, and Integrated Optics. The leader of the former is Professor Dr. C. Baack (who is also one of the two managing directors of the entire institute), and the head of the latter is Professor Dr. A. Schlachetzki. (My review is based mainly on interviews with these two scientists.) The research activities, irrespective of the division which pursues them, can be summarized as follows:

- Broadband communications (VLSI, video coding, universal network [optical long-haul and subscriber systems], optical LAN's)
- Integrated optics (InP technology, $LiNbO_3$ studies)
- Optical signal processing (digital processors and converters)
- Broadband services (videophone, high-definition TV with light valve system, three-dimensional TV)
- Subsidiary, social research (human engineering)

Before selecting a few activities for description, I draw attention to the unusually rich equipment and facilities that the institute has on its premises (a 15-story tower). They have liquid phase epitaxy, metal organic chemical vapor deposition, and molecular beam epitaxy capabilities; they possess a fine (0.2-μm resolution) electron beam direct-writing machine (and also e-beam lithography), holographic technology, and near-UV photolitography. A broad range of process-technology equipment (including 400-keV ion beam implantation and plasma sputtering capabilities) are provided. An unusually rich spectrum of measuring, testing, and characterization gear (including two scanning electron microscopes of very high resolution) complete the list of major assets.

Coherent Optical Communication. This is Professor Baack's pride, and the current focus of the systems division's work. The main interest is not so much in the improved sensitivity aspect of this methodology, but rather the amazing multichannel capability. (With coherent transmission and heterodyning, well-developed microwave techniques can be used.) The institute has now built a complete 10-channel coherent transmission-receiver system prototype. The 10 channels are amplified together by purely optical (diode laser) amplifiers. In order to avoid cross-talk, phase shift keying (frequency modulation) technology is used. Further work will consider not only the linear, but also the nonlinear coherent communication methods. These are considered to play a prominent role in a 5- to 10-year perspective. Besides the current coherent data communication efforts, the institute is also involved in the European RACE project on multichannel TV distribution (up to thousands of channels!) with coherent techniques.

Optical Signal Processing. While no plans are made to consider optical computing in the "radical" sense, the institute is much interested in inherently combined electrical and optical signal processing, with broadband communication applications being the primary motivation. Currently the emphasis is on signal processing suitable for later monolithic integration. Hybrid optical processors, temporarily using $LiNbO_3$ technology, have been constructed. Moreover, the leadership-involvement of the H. Hertz Institute (as noted earlier) in the federal German nonlinear optical bistability project, has already led to both theoretical and experimental research with a Fabry-Perot resonator-type switching element. While this research used II-VI materials, future work will focus on III-V materials, so as to allow eventual combination with the corresponding integrated optics research.

Integrated Optics. Focused work in this area has been going on only in the last 4 years, yet substantial advances have already been registered. The institute's philosophy is firmly committed to the use of InP technology. The main

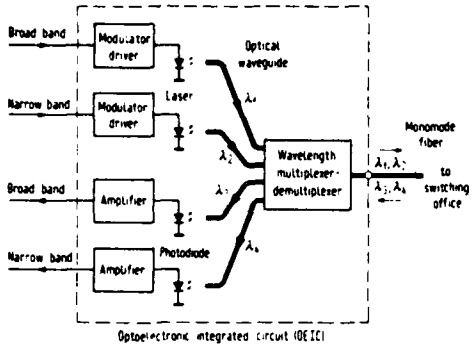

Figure 1. Schematics of an integrated wavelength-division multiplexing circuit.

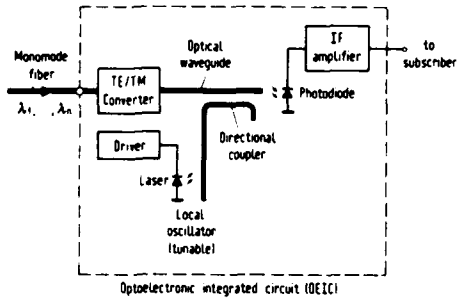

Figure 2. Schematics of an integrated coherent optical receiver.

reasons are that InGaAsP/InP devices are simple to grow, have low attenuation in the crucial 1.3-μm and 1.5-μm regions, have vanishing dispersion around 1.3 μm, and are less sensitive to aging caused by dislocation-growth than are GaAs based systems.

The research group (employing about 80 researchers) has already achieved considerable skill in InP technology which, they think, is only 5 years behind GaAs technology. They can fabricate high-quality bipolar transistors, lasers, photodiodes, waveguides, waveguide mirrors, phase modulators, TE/TM converters; they were successful also in p-i-n/FET integration and in p-i-n/waveguide integration. The group has had only partial success so far with monolithic combination of the listed components on a single chip: while they have demonstrated all crucial integrations, the uniformity of the chips and their reproducibility is poor. But the researchers are confident that it is only a technological (not basic research) task to overcome these problems.

The scientists have now started the next phase of their work and are about to build the first laboratory units of complete wavelength-division multiplexing circuits for use in the subscriber area (Figure 1). They are also ready to build a fully integrated coherent optical receiver for subscriber use (Figure 2).

7/25/87

PHYSICS AND MICROELECTRONICS RESEARCH AT THE INSTITUT SUPERIEUR D'ELECTRONIQUE DU NORD

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

Introduction

The Institut Superieur d'Electronique du Nord (ISEN) in Lille is an institution in France that is both a private engineering school and a research institute. Founded in 1956 by N. Segard, it now has a professional staff of 60 with an engineering student body of 560 and with another 100 in the preparatory program. ISEN is a member of a group called Polytechnicum de Lille, which consists of five private engineering schools. This group shares some facilities such as the central library.

ISEN's educational program is a typical 5-year curriculum consisting, first, of a preparatory program of 2 years conducted by the 1'Ecole Superieure Professionnelle Ozanam de Lille--with strong emphasis on mathematics and physics. The remaining 3-year program consists of the engineering cycle where there is heavy emphasis on computer science, electronics, telecommunications, and control theory. In the final year the students participate in an industrial project and about 100 graduates a year receive over 1500 employment offers.

ISEN's research institute is divided into four departments. The research activities of the Department of Physics and the Department of Microelectronics are closely coordinated through an internal research group called Laboratoire D'Etude des Surface et Interfaces de La Federation Universitaire et Polytechnique de Lille. This laboratory is supported by the Centre National de la Recherche Scientifique (CNRS) and is called Laboratory 253 CNRS. The other two departments are the Department of Informatics and the Department of Robotics and Control.

Department of Physics

Dr M. Lannoo is head of the physics department and director of LA253-CNRS. There are four subdivisions in the department, providing a nice balance between a theoretical solid-state physics group of six people and two solid-state experimental groups of seven members. The largest group of 12 is concerned with acoustics.

Theoretical Solid-State Physics. The central theme of study in this group is the electronic and vibrational structure of perfect solids with point defects of their surfaces and interfaces. The solids may be semiconductors, binary or ternary compounds, and transition metals. Publications are mostly in English and appear principally in *Physics Review B*. Titles of two recent articles are: "Photoionization cross sections of deep level defects in semiconductors" and "Nature of covalent bonding of self interstitials in silicon".

Recent emphasis using the theory of tight-binding has been on the electronic properties of semiconductor superlattices and heterojunctions in which the aim has been to develop semiquanitative and quantitative models with a strong informational content. Although the study can be characterized as fundamental, the work is guided by practical applications. Superlattice semiconductors are becoming important components in microelectronics and optoelectronics.

The group has close liaison with several theoretical and experimental groups which include Spectrimetrie Physique de Grenoble, Ecole Normale Supérieure (ESN, Paris), Centre National D'Etude Telecommunication (CNET, Lannion and Bagneux), and several universities (University of California at Irvine, University of Madrid, et al.). The group uses an IBM 4341 Model 2 computer.

Experimental Solid-State Physics. The experimental solid-state physics group is divided into two subgroups. The first subgroup, headed by Dr. D. Stievenard, is concerned with the characterization of point defects in semiconductors and semiconductor devices. This effort began in 1979 out of a collaboration between Professor J. Bourgoin of ESN and Lannoo. The subgroup is very familiar with the application of deep-level transient spectroscopy (DLTS) to the study of point defects introduced by electron irradiation of GaAs and to the study of defects of semiconductor-insulator interfaces. The DLTS technique consists of filling the defects in the semiconductor with free carriers by means of an electric impulse and analyzing the transitory regime from which the activation energy, capture cross section, and concentration can be obtained. Deep-level optical spectroscopy (*DLOS*) is a similar technique used by the group except that optical excitation is involved. The laboratory is well equipped with four *DLTS* setups, an electron paramagnetic resonance and electron nuclear double resonance device (EPR-ENDOR), a *DLOS*, and several conductance technique devices. The group publishes in English in such journals as the *Physics Review*, *Journal of Applied Physics*, and *Journal of Physics*. Recent titles include "On defects profiling using deep level transient spectroscopy" and "Oxide traps in $Si-SiO_2$ structures characterized by tunnel emission with DLTS".

Current emphasis is on superlattice and heterojunction semiconductors; there is thus a synergistic effect with the analysis of the theoretical group. Contracts in this area are from Laboratoire Central de Recherche (LCR), Thomson, Groupement Circuit Integre Silicium (GCIS), Ministére de la Recherche et Technologie (MRT), and CNET (Bagneux). This subgroup also has extensive collaboration with universities and research laboratories in France as well as IBM in America.

The second subgroup, headed by Dr. G. Dalmai, is concerned with the characterization of surfaces and interfaces of semiconductors by means of electron spectroscopy and by means of scanning electron microscopy. Research is directed at the carbon-silicon bonding, at metal silicon and silicide-silicon interfaces, and at catalytic and passivation effects. Further work is being directed at the kinetics of oxidation of silicides (Ti and silicides). The subgroup has two electron spectroscopes, an Auger electron spectroscope (AES), and a low-energy electron diffraction (LEED) apparatus. Information is obtained on the composition of the surface, on chemical reactions on the surface, and on the density of the electron states on the surface. They are also using acoustic excitation to characterize surfaces and, in fact, one of their recent publications is titled "Characterization of Silicon and GaAs surfaces by acousto-electric technique." They have contracts from CNRS and GCIS and collaborative arrangements with, among others, CNET, Laboratoire de Mineralogie (Strasbourg) and Laboratoire de Cristallographie et Etude de l'état Solide de Gand (Belgium).

Acoustics Laboratory. The acoustics laboratory along with the theoretical solid-state physics group was the first research laboratory founded by N. Segard before he started ISEN. This may explain the strong emphasis on research that I found at ISEN. Dr. J. Decarpigny, who is the director of the acoustics laboratory,

was my host for my visit to ISEN. (I had met him previously--while he was at the Naval Postgraduate School where he was working with Professor B. Wilson in acoustics.) The work of the acoustics laboratory has definite Navy applications. The scope of the laboratory includes the analysis and design of sonic and ultrasonic transducers and the numerical modelization of piezoelectric transducers by means of the finite element method. Most of the studies emphasize the applied aspects of underwater acoustics, and studies are also ongoing in applications of ultrasonic machining.

The numerical modeling work has been supported by the collaborating Groupe d'Etude et de Recherche en Détection Sous-marine (GERDSM) in Toulon, France, as well as the Direction des Constructions et Armes Navales (DCAN-Toulon). Numerical modeling of piezoelectric transducers requires the use of three-dimensional methods. Since 1979 Decarpigny and his associates have developed a computer code, ATILA (Analyse de Transducteur par Integration des Equations de Laplace), which permits a complete description of the mechanical displacements, the electric field, and the acoustic pressures. This code is unique in France, and it rivals similar codes in America. It yields a complete modal analysis of all systems. A quadratic variational method with isoparametric elements and quadratic interpolation is used in developing the model. Provision is made for automatic grid generation and for extensive graphical displays. A recent article in this area is titled "Analysis of acoustically radiating piezoelectric Tonpilz transducers in a wide frequency band using a mixed finite element-plane wave method." Provisions are now being made for the US Navy to adapt the ATILA code for its use.

The experimental capabilities of the laboratory have been materially extended by the addition of a new pool for measurement of acoustical signals. The pool is 8×6×6 m and has a frequency capability in the range greater than 3 kHz. Completely automatic acoustic-electrical measurements can be performed in the pool. This pool is, thus, a research tool in the other activity of the acoustics laboratory, i.e., the analysis and development of sonic and ultrasonic transducers. New ideas for acoustic transducers both in geometric configuration and in materials are being tested in the pool. The laboratory has the capability of fabricating transducers.

Future work of the laboratory will be directed at the development of new directional hydrophones such as polymer piezoelectric devices, at the development of new methods of measuring underwater acoustics such as impedance tubes, and at the completion or extension of the ATILA code.

Department of Microelectronics

There are three research groups in the microelectronics department, all with a strong orientation towards applied applications and the use of computer aided design (CAD). Interestingly enough, the teaching in the microelectronics area--at least as far as an advanced option in the fifth year--was introduced as a result of the research activity.

Research activities in the first two groups started in the department of microelectronics in 1980 through a collaborative effort with Professor Jespers of Catholic University of Louvain-la-Neuve, Belgium. These groups work on bidimensional simulation of silicon technologies using the finite element method and on the design of analog integrated circuits. The head of the first group is Dr. D. Collard, who is also head of the department. This group is oriented towards the simulation of the different stages in the fabrication of integrated circuits in which lateral phenomena are important. Emphasis is thus on two-dimensional simulation and the optimization of the technological steps involved. Extensive use of computer aided design (CAD) methods is used in the resolution of technical problems. A CAD computer code called MOBIDIC has been developed. MOBIDIC, in a two-dimensional region, can simulate completely the stages in the doping of silicon with arsenic, boron, or phosphorous. The program can simulate ionic implantation, predeposition, recruitment of N_2, H_2O, and O_2 and engraving and deposits of SiO_2. Many of the computer simulations have been validated later by experiments. Another computer code, MINIMOS (Technical University, Austria), has been interfaced with the ISEN code in order to characterize MOS technology. The ensemble MOBIDIC/MINIMOS has been tested on MOS 3- and 2-micron technology at Matras-Harris and Toshiba as well as at the Catholic University of Louvain-la-Neuve. Two other computer codes are being used by the unit: SUPREM II (Stanford, California) and TITAN (CNET, Grenoble). The group has contracts from GCIS and CNET (Grenoble). Future work of the group will be directed at extension of the simulation process to CMOS, NMOS, and PMOS technologies. Further work is also planned on the modeling of polycrystalline silicon.

The second group's activities are directed at the design of MOS analog integrated circuits for several specific applications in measurement devices. The designs have included amplifiers with

very small noise levels and small energy consumption and special capacitance filters. Again, extensive use of CAD is involved with computer codes to simulate electrical and logical behavior and with other codes that are used in the design of masks. One of the primary codes used is that of SPICE, which was developed at the University of California, Berkeley. A Textronic 4115 is used as a graphics terminal in the design of the masks with supporting computer codes (see section on informatics, below). The group has contracts from GERDSM and Agence Nationale de Valorisation a la Recherche (ANVAR), among others.

The third microelectronics group is concerned with use of ultrasonic waves in the field of machining. This group has three working areas: the design and construction of programmable power generators, the application of ultrasonic waves in industry, and the improvement in the basic electronic circuits of ultrasonic and power generators.

Department of Informatics. The computer science laboratory was created to further three specific research topics in computer science. These are:

- The development of CAD software
- The development of expert systems in the medical and banking field as well as in CAD
- The advancement of image processing.

One of the department's specific objectives is to answer regional industry requests and also to serve a supporting role in the exploitation and management of computer software for the other research groups. The laboratory works in close cooperation with the microelectronics groups and has assisted in the development of two computer codes used in the development of circuits and the verification of masks in fabrication. The code ELODIE is based on the graphical kernal system (GKS). The product or code is concerned with the production of masks for the fabrication of integrated circuits. The code considers the integrity of the hierarchical design and the connectivity and crowding of cells on the base. Another program, VEGA, verifies that the correct geometry is used in the construction of the circuit while a third program, ESTEL, extracts the electrical schematic which is used in simulation of the electrical part of the circuit. Finally, the logical structure is obtained by means of a code obtained elsewhere--EPILOG (Simulateur logique de Thomson-EFCIS). A recent publication in this area was titled "ELODIE, un editeur de masque base sur la norme GKS."

Expert systems are being developed in connection with a local hospital. The object of these systems is to aid in the selection of a treatment for hernia. In addition, fundamental studies are also being conducted on the use of natural language and the covalidity of expert systems. In the case of image processing, work is underway to improve the resolution of echographs.

Department of Robotics and Control. The robotics and automatic control laboratory has three current topics of investigation:

- Robotics and its industrial application
- Real-time data processing systems
- Automatization of industrial processes.

In the case of robotics the emphasis is on the robotization of previously manual operations. The vehicle on which these studies are based is the IR6 robot of the Swedish firm ASEA. Feasibility studies with Industrial Commercial d'Application Modernes (I'CAM) for handling pieces of aluminum and automobile parts have been conducted. Evaluation of the performance of the protocols developed is now in process. In another aspect of robotics, in collaboration with the Centre de Resource pour l'Ensignement de la Productique (CREP) of Valenciennes, the laboratory is engaged in the modeling of the geometry of the environment of the robot. The object is to interdict certain volumes of space about the robot for security and machine interference reasons. Further work is being done on the trajectory analysis of robot motion in collaboration with Electronic Systems Industry (ESI). This requires the solution of a system of 12 nonlinear equations in six unknowns. A recent publication in this area is "Un simulateur graphique pour la programmation de cellule de soudage robotise; l'apprentissage hors ligne."

Commercial Spin-off Companies

ISEN's work has generated the development of three different commercial enterprises. In 1986 a commercial enterprise called SLICE (Sociéte Lilloise d'Industrialization et de Commercialzation Electronique), which is included in the framework of l'ANVAR, was initiated on the basis of ultrasonic work in the microelectronics department. The purpose of this company is to transfer to industrial sites the power generation and ultrasonic devices developed at ISEN. SLICE is international in that it is in partnership with the American company, EXTRUDE HONE, of Pittsburgh.

The SINAPTEC (Simulations Numeriques Applications Technologiques) company originated out of the acoustics laboratory in 1984. The objective of this company is to promote the use of ISEN's finite element code ATILA. Three engineers that work in the acoustics laboratory are supported by SINAPTEC. The management of ISEN views collaboration with SINAPTEC as an excellent example of a means of transferring laboratory-developed technology to national or international industry. The third company, called ICE (Informatique et Conseils aux Entreprises), was established in 1985 with the help of l'ANVAR, a French governmental agency which fosters university and industrial exchanges. The creation of ICE coincided with the introduction of an electronic directory with videotext display devices. The researchers in the department of Informatics are involved in the ICE company. The company now has close relationships with many of the municipalities in the north of France who are tied in to the electronic directory.

The fact that three companies have been created out of the research effort at ISEN in a 3-year span indicates a very dynamic research environment. It is also interesting that the companies continue to have a close working relationship to ISEN. This probably reflects the influence of l'ANVAR.

Conclusion

The solid-state physics work at ISEN is of a fundamental nature and very productive. In a recent year there were 14 open-literature publications in American journals. A remarkable synergistic effect exists between ISEN's experimental and theoretical work. The acoustics laboratory is also doing excellent work in the analysis and development of hydrophones and ultrasonic transducers.

The microelectronics department is engaged in more applied research so that less open-literature publications have been produced. I was impressed, however, with their use of CAD in solving their problems. The two departmental research efforts connected with LA-253-CNRS, form the solid foundation upon which the research at ISEN is built.

The informatics department seems heavily involved in the industrial base of northern France and is involved in very current research closely related to the effort in the microelectronics department.

Finally, the robotics department is attacking the type of problems that I have observed in other good robotics departments in Europe, but I had the impression that this was somewhat of a new activity for ISEN.

ISEN is surprisingly like an American research institute in its outlook and in the way it has spun off small companies--and this coincident with the fact that a large part of its effort is in teaching. In its teaching, the institution is also supplying a vital national need by educating students in electronic and computer science. It was a pleasure to visit such a dynamic institution.

7/17/87

Space Sciences

THE FEW-BODY PROBLEM--IAU COLLOQUIUM NUMBER 96, TURKU, FINLAND

by CAPT Dale G. Bettis, USNR. CAPT Bettis is a Reserve Officer with a background in celestial mechanics, mathematics, and numerical analysis. He is the Commanding Officer of the ONR Houston Unit.

This colloquium, organized by The International Astronomical Union (IAU), considered various aspects of the gravitational N-Body problem. It was sponsored jointly by four IAU Commissions: Celestial Mechanics; Positions and Motions of Minor Planets; Comets and Satellites; Structure and Dynamics of the Galactic System; Star Clusters and Associations.

It is well known that the backbone of celestial mechanics has been the celebrated three-body problem. This is still popular and a great deal of effort has been put forth in investigating various aspects of the general or restricted versions of the problem.

In recent years applications of the three-body and several-body problem have come into wide use in many fields of astronomy. The methods of the few-body problem have been applied to problems, for example, in the solar system, multiple star systems, star clusters, interacting galaxies, nuclei of galaxies, and clusters of galaxies. Even though the physical situations vary greatly, the methods are often very similar.

The purpose of the colloquium was to bring together people working both on analytical and on numerical aspects of the gravitational few-body problem, both on fundamental theory and on applications, and in the whole range of the applications. While the gravitational

N-body problem has been treated several times in IAU colloquia and symposia, the "few-body problem" has never been the subject of such a meeting. The emphasis in Colloquium Number 96 was on systems with N less that 10, as well as larger systems where the basic processes may be modeled by few-body interactions.

The colloquium consisted of nine half-day sessions with 11 invited reviews and 57 contributed papers.

General Methods

C. Marchal (ONERA, France), began the meeting by stating that in celestial mechanics, as in many other fields, quantitative and qualitative analyses are complementary. The quantitative analysis gives excellent information of the particular solution of interest, but does not provide a general solution valid for any range of time. Additionally, for long periods of time, the quantitative solutions degenerated as a result of an accumulation of numerical errors. To the contrary, the qualitative analysis yields rigorously defined properties that are valid for very long periods of time, and generally, for infinite periods of time.

The qualitative analysis especially deals with the questions of integrals of motion, symmetries, periodic orbits, final evolutions, structure of the set of solutions, analysis and regularization of singularities, escaping motion, bounded motions, oscillatory motions, asymptotic motions, etc.

The recent increases in computing speed and memory size of computers have led to many improvements in the quantitative analysis of the N-body problem. These improvements have disclosed the extreme complexity of the set of solutions and have given new orientations and a new impetus to the qualitative analysis, especially in the domain of the final evolution of the system, and the criterion for escape.

However, the three main conjectures of the N-body problem remain open:

1. The Poincaré conjecture (the periodic orbits are dense in the set of bounded orbits)
2. The Arnold diffusion conjecture (for noninfinitesimal masses the escape orbits are everywhere dense in phase space)
3. The conjecture on the structure of the set of solutions (for noninfinitesimal masses almost all bounded orbits are quasiperiodic and belong to the Arnold tori).

A review was presented by J. Hadjidemetriou (University of Thessalonika, Greece) of periodic orbits which are of a general interest to dynamical astronomy: planetary systems with two or more planets, the asteroid system, stellar systems, and the motion of a star in various types of galaxies.

Most systems are close to integrable ones, and the properties of the existing families of periodic orbits can be found by studying the continuation of the families of periodic orbits of the unperturbed system. The evolution of the stability properties from the unperturbed to the actual system was also studied, and in this way the relation between resonance and instability or nonintegrability and instability is revealed.

The qualitative differences which appear as the number of degrees of freedom is increased, and the factors which affect the stability was analyzed. For example, Hadjidemetriou showed that a planetary system with three planets is always critical when the masses are negligible because a Hamiltonian perturbation always exists, which generates an instability. This is contrary to the two-planet case which is critical only at particular resonances. If, however, in a system of three planets in circular orbits where the mass of at least one is not small, stable periodic motion exist.

Perturbative Methods

J. Henrard (University of Namur, Belgium) noted that resonances in the restricted circular three-body problem usually led (by averaging) to one-degree-of-freedom Hamiltonian systems described by the Hamiltonian Ho(P,p).

Consideration of a further degree of freedom (as a fourth body or the ellipticity of the orbit of the perturbing body) may introduce a second critical argument (q) in the averaged system which will then be described by the Hamiltonian:

$$H=Ho(P,p) + eH_1(P,Q,p,q)$$

A seminumerical perturbation method was developed to deal with such systems even when the "unperturbed" Hamiltonian Ho possesses critical curves in the region of interest.

Computer Algebra

A. Ollongren (Leiden University, the Netherlands) gave an account of three bodies of equal mass, m, which revolve in a plane around their gravitational center in circular orbits under the influence of their mutual gravitational attraction; at the center a mass of βm is present, where β is greater than zero. A fifth body of negligible mass compared to m, moves in the plane under the gravitational attraction of the other bodies. The problem is to determine the motion of the small body.

Ollengren discussed the existence and location of the Lagrangian equilibrium points, and said that the motion in the vicinity of these points is characterized analytically by using tools from computer algebra. Specifically, he derived the equations of motion of the fifth body in the synodic coordinate system by using the syntactic conventions of mu MATH, produced by Soft-Warehouse in Honolulu.

The resulting analysis showed that the central mass has a stabilizing effect on the motion of the fifth small body, provided its mass is large enough. The mass ratio (mass central body/mass other body) = 44, is critical. For mass ratios larger than this value, three of the nine Lagrangian points of equilibrium become stable, and the fifth body will carry out a liberational periodic motion around each of them. for smaller ratios all points of equilibrium are unstable.

Quantitative Methods

A. Milani and A.M. Nobili (University of Pisa, Italy) gave a summary of their numerical integration of the outer planets. This second phase of Long-term Gravitational Stability test for the Outer Planets (Project LONSTOP), extends to 100 million years, compared to an earlier simulation of 9.3 million years. Both studies were computed with a Cray 1S.

These investigators' N-body point mass Newtonian approximation of the outer solar system neglected tidal friction and the J_2 terms for the planets. They concluded that the analysis of shallow resonances in mean motion was easy, but that secular resonances were difficult. With these ideas in mind, they selected N to be six, and included a correction for the inner planets in their model. Also, they corrected for the secular perihelion advance for Jupiter predicted by general relativity. Their general philosophy was that numerical integrations are not easier than analytic theories, but do allow the discovery of real features of the dynamical system. However, whenever possible, they did compare the integrations with analytic theories.

Their equations of motion were formulated with Encke's method. A predictor-only method with 12 differences was used for the numerical integration. The limiting factor for the integration was round-off error. The error in the energy was approximately $1.3 \times E10^{-8}$, and was characterized by an inverted V-shaped curve, with the peak at time zero. The linear curves each had different slopes. There was no explanation for this phenomenon.

Milani and Nobili concluded that their final solution could be represented as a multivariant Fourier series with the independent variables linear functions of time. Their "optimistic prediction" was that any problem remaining with the study of the dynamics of the solar system will be solved by a longer integration, so long as they can manage to keep the round-off errors small.

In their closing remarks they observed that Poincaré stated, in the period 1889-1892, that the perturbative series of celestial mechanics do not converge on *any* open subset of the phase space (i.e., it seems that one eventually reaches a time where there exists a divisor that is small). Also, Poincaré, in 1893, noted that once the initial conditions are fixed, the perturbative series are *always* divergent. The crucial question is whether this happens before or after the completion of the integration. Thus, the problem of the stability of the solar system is still open.

Mari Carpino (Astronomical Observatory of Brera-Merate, Milan, Italy) used the results of the LONGSTOP project to show that the semimajor axes of the outer planets undergo secular variations over time scales of millions of years, with relative amplitudes of the order of 1.1×10^6. The most interesting case was an almost exact energy exchange between Uranus and Neptune with a period of 1,107,000 years, the same period of the angular momentum exchange between Jupiter and Uranus.

A classical theorem by Tisserand states that these variations must be at least of the second order in the small parameter represented by the ratio of planetary mass to the sun's mass, and of second degree in the eccentricities, or inclinations, but for Uranus and Neptune these values are too small to account for the observed variation.

Using a Lie series transformation approach, Carpino computed the term responsible for the Uranus-Neptune energy exchange, and showed that it is greatly enhanced by the small divisor of the mean motion shallow resonance between Uranus and Neptune, appearing to power 3 in the amplitude. This computed value agrees with the results of the numerical integration within about 20 percent.

Statistical Methods

J.J. Monaghan (Monash University, Australia) stated that the statistical description of small N-body systems by means of the classical microcanonical ensemble gives reasonably accurate predictions but at the cost of considerable complexity. The analysis is greatly simplified if the canonical ensemble is used. He gave analytical results and discussed the agreement with numerical experiments.

Numerical experiments were performed by Seppo Mikkola, Turku University Observatory, Finland, in order to study the influence of different masses on the three- and the four-body problems. Particular attention was addressed to the probability of the escape of various masses and the resulting energy distributions.

The probability of escape of a certain mass from an unstable three-body system may be approximated by a series with the angular momentum as the independent variable. However, difficulties occur if this variable becomes small. In four-body systems the mass-dependence was found to be less than in three-body systems. A surprising result was that the energy distributions seem to be independent of the masses, unless special initial conditions or very large mass ratios are considered.

Kirkwood Gaps

Henrard's method (above) was used by A. Lemaitre (University of Namur, France) to unravel the complexity of the motion of asteroids in the Jovian 2/1 resonance taking into account the eccentricity of Jupiter. The method utilizing the two critical arguments was applied to the problem of the Kirkwook Gaps. The model selected was the plain, eccentric-restricted three-body problem. The aim of this study was to determine the width of the regions of possible chaotic motion in the case of the 2/1 resonance, and therefore test the gravitational hypothesis for the formation of the gaps.

She concluded that chaotic motion can appear in two different ways: first, by crossing the critical curves of the circular model, and secondly, by being in the regions where super-resonances act. These conclusions were in agreement with numerical studies.

Nevertheless, those regions were not very large and the motion was limited by the constant energy curves. Finally, the gravitational mechanism did not seem to work as well as in the 3/1 resonance case, and additional nonconservative effects must still be added to deplete the resonance zones.

The motion of an asteroid located near the 5/2 resonance with Jupiter was investigated by M. Sidlichovosky (Astronomical Institute of the Czechoslovakian Academy of Science, Prague) using a mapping based on the Method of Wisdom. Two modes of motion were found, one with a low and one with a high eccentricity. Transition between these two modes was possible.

The chaotic zone is investigated using Liapunov characteristic exponents. The reliability time for trajectories in the chaotic region, where the round off error propagates exponentially, was estimated as 3.2×10^5 years.

The transition between the modes was discussed in terms of the Wisdom zone of uncertainty. As the eccentricity in the high mode exceeds 0.4, there is evidence that asteroids are removed from the gap as a result of collision.

Rotational Motion

Rotational motion of a rigid-body located in an orbit of the three-body problem in terms of Hamiltonian mechanics was considered by A.J. Maciejewski (Nicolaus Copernicus University, Poland). This problem was compared with the well-known case of the rigid satellite moving in an elliptic orbit. Special attention was paid to refine differences of these two cases.

It was shown that if the body under consideration is located in a colinear libration point, simple rescaling reduced one case into another. All stationary solutions for symmetrical bodies located in a triangular libration point were found, and their stability examined. When the mass center of the body moves in an infinitesimal periodic orbit around a triangular point was also investigated.

Reference Frames

S.Y. Zhu (Shanghai Observatory, China) discussed the problem of motion of satellites in the relativistic framework. Motion of artificial satellites of the earth can be solved either in the solar system barycenter reference frame or in the terrestrial reference frame. The results of solutions in frames were compared in detail.

After taking the relativistic coordinate transformation into account, Zhu proved that both solutions are equivalent at the practically required accuracy level. Finally, it was shown that when the observations are related with some distance sources (stars in the optical observations of a satellite) the terrestrial frame can still be used without any perceivable accuracy degradation, compared to the solution in the barycenter frame.

Stellar Systems

N.A. Solovaja (Moscow State University, USSR) applied a theory developed by A.A. Orlov and herself to a system of the ε Lyr's type. They defined their stellar problem as a particular case of motion of three points moving in orbits in which the separation of two of the bodies is much less than the distance of either from the third. The masses of bodies are comparable, the eccentricities may have any value between 0 and 1, the mutual

inclination may have any value between 0 and 190 degrees.

The applications of the von Zeipel method to the equations of motion allowed the possibility of excluding the two angle mean anomalies, from the Hamiltonian of the system.

By using the Hamilton-Jacobi method, the solution of the system was formulated in terms of hyperelliptical integrals. This solution was used to construct an analytical theory of motion for the triple system. The theory was applied to a triple system in UMa. The average change per century in elements compared favorable with the observations.

In general, Solovaja and Orlov's theory is applicable to the study of the evolutionary changes of components of triple stellar systems.

It is known that visual and photographic observations of stars can not show whether the node is ascending or descending. Calculations resulting from their formulas can offer a solution to this problem. Also, their solution can indicate the stability of the system.

Galaxies

A dynamical model for the polar ring in a galaxy (NGC 4650A) based on H alpha observations using a Taurus instrument, was presented by L. Sparke (Kapteyn Laboratory, the Netherlands). The ring was represented as a collection of massive concentric circular wires, moving in the axisymmetric gravitational field of the SO galaxy, and mutually attracting by their own gravity. Such systems can have equilibrium states, in which the ring precesses uniformly as a solid body about the galaxy; in this case the structure persists essentially forever.

The ring in NGC 4650A was not in equilibrium, but was being twisted by differential precession in the field of the SO galaxy. Comparison with models suggested that the ring could indeed be understood as a self-gravitating structure. The outer parts of the ring have had time to make two or three orbits about the galaxy. Most of its mass must be at large radii in order to reproduce the observed warp towards the pole. The ring probably formed by accretion of a gas-rich cloud onto a nearly polar orbit around the SO galaxy, a few times 10^9 years ago.

Concluding Comments

This IAU Colloquium was most successful. The mix of diverse specialists, all with a working knowledge of some form of the N-body problem resulted in a stimulating and creative environment. Adding to the group of senior scientists was a large number of impressive young investigators, including a few graduate students. These bright, energetic, and articulate (in English) scientists seem to be emerging from throughout Europe and the Far East.

On the fourth evening, by popular demand, there was a special round table discussion about chaotic motion. Although no revelations were forthcoming, the session did focus on the difficulties inherent to the N-body problem.

There were approximately 100 participants, representing 23 countries. While seven papers had been accepted from the USSR, only two of their scientists actually participated.

The Local Organizing Committee, chaired by Professor M. Valtonen, Turku University Observatory, are to be complemented for their excellent work, and for the genuine hospitality.

The proceedings of the colloquium will be printed by Reidel Publishers, the Netherlands, in the *Astrophysics and Space Science Library Series.*

6/30/87

News and Notes

A NEW JOURNAL ON ANXIETY ANNOUNCED

A new journal on anxiety will become available in early 1988. Titled *Anxiety Research: An International Journal*, it will be edited by Dr. Ralf Schwarzer of the Freie University of Berlin, West Berlin. Coeditors are Henk van der Ploeg of the University of Leiden, Irwin Sarason of the University of Washington (Seattle), and Charles Speilberger, University of South Florida. The quality of the editorial board, which contains world leaders in anxiety research, should guarantee a high-quality scientific product. The journal "will provide a forum for scientific, theoretically important, and clinically significant research reports and conceptual contributions" on anxiety. It will be focused on experimental studies of anxiety arousal, the measurement of anxiety, and meta-analyses of the anxiety literature. Clinical case studies are not likely to be included in the journal, given its experimental orientation. Articles will be in English. The journal will be published four times per year, and the personal subscription price is $52. Requests for sample copies or

orders can be addressed to Harwood Academic Publishers, PO Box 786 Cooper Station, New York 10276.

William D. Crano
7/30/87

THE CYTOSKELETON RESEARCH IN CELL DIFFERENTIATION AND DEVELOPMENT IS REVIEWED

The first international symposium on the cytoskelton in cell differentiation and development was held in Granada, Spain, from 21 through 25 April 1987 at the Faculty of Medicine, University of Granada. This specialized conference had been organized jointly by J. Arechaga (Department of Cellular Biology, University of Granada) and R.B. Maccioni (University of Colorado Health Sciences Center, Denver). This joint venture was reflected in the fact that of the total of 95 participants, 38 percent were from Spain and 26 percent from the US. The balance of attendees represented eight European countries as well as Chile, Israel, and South Africa.

The elucidation of the structural-functional aspects of early development and cellular differentiation are among the most challenging problems in modern biology. The developmental aspect of the cytoskeleton is clearly one of the relevant aspects of this rapidly growing research field. Research on cytoskeletal structure and organization has been a rewarding area of investigation, exhibiting an explosive growth of scientific ideas and information during the past 15 years which has contributed to an understanding of the biological complexity of cytoplasmic organization and the intracellular dynamics. Especially, multidisciplinary approaches have impacted and stimulated research in many fields of biological sciences including cell biology, biochemistry, and molecular and developmental biology. Thus, within the framework of the perspective of epistemologists the organization and assembly of the cytoskeleton constitutes a major conceptual scheme of modern biology.

The detailed cellular and genetic aspects of embryogenesis were discussed in several plenary lectures while the developmental aspects of cancer research were the subject of a symposium session. The structure and regulation of microtubules and their internal organization in differentiating cells and embryos was also a major topic of the symposia. Further analysis of these regulatory aspects in the light of microtubule-associated proteins (MAP's) and the interactions of cytoskeletal components were also developed in the various sessions of the conference. Besides the control of the activity and organization of the cytoskeleton by multiple protein factors and ligands, the manner in which gene expression for different cytoskeletal components is regulated is also a crucial aspect of the analysis of the cytoskeleton in embryonic development. Developmental expression of tubulin, MAP's, and intermediate filaments as well as the molecular genetics of embryogenesis were also discussed throughout the meeting. Due to the contribution of cytoskelton research to developmental neurosciences, a special session was devoted to analyzing the organization of the cytoskeleton in differentiating neurons, astroglia, and neuritelike processes.

This intensive and very interesting conference covered the molecular, cellular, and genetic basis of the role of the cytoskeleton in cell differentiation and development. The broad area covered by this topic stresses the importance of the interdisciplinary bridges connecting modern cell biology and biochemistry in experimental embryology. Enormous progress has been made in this area due to a large extent to the excellent techniques now available such as immunological techniques, recombinant DNA technology, and sophisticated methods for protein purification and analysis. The presentations focused on the analysis of the assembly dynamics of microtubules, intermediate filaments, and actin filaments to provide the structural basis of the role played by the cytoskeleton in the differentiation of a variety of cell systems, early embryogenesis, and to the biological and genetic aspects of cytoplasmic organization.

A detailed account of this conference on the Cytoskeleton in Cell Differentiation and Development is presented in ONRL Report 7-024-C.

Claire E. Zomzely-Neurath
6/27/87

NEW JOURNALS IN BIOLOGICAL SCIENCES

Seven new journals in the biological sciences plus an important new section to be added to an established journal have recently been announced. Following are details.

Enzyme Inhibition

The *Journal of Enzyme Inhibition* is an international and interdisciplinary vehicle publishing new knowledge and findings on enzyme inhibitors and inhibitory processes. It publishes research papers, short communications, and reviews on current developments across the disciplines of enzymology, cell biology, microbiology, physiology and pharmacology, drug design, and biophysics. Among the various fields of enquiry, special attention is given to structural and molecular studies, kinetics and inactivation mechanisms, structure-activity relationships (including QSAR and graphic techniques) within a chemical series or group, drug development studies, and control mechanisms in metabolic processes.

The Editor-in-Chief is H.J. Smith, The Welsh School of Pharmacy, Cardiff, Wales. The journal will be published by Harwood Academic Publishers, London, UK, and New York, US. The corporate subscription price per volume (four issues per volume) is $270; university/academic library price $168; and individual subscription $84.

Protein Sequences and Data Analysis

Protein Sequences and Data Analysis is devoted to the publication of newly determined sequence data and to the organization, retrieval, and analysis of this information using data banks. The journal will consist of four parts:

1. "Sequencing Results," reporting the experimental determination of new protein sequence data. Partial sequences, often of great importance in sequence comparisons or in nucleic acid work are included, as are protein sequences determined indirectly by DNA sequence analysis when experimental evidence for the existence of the protein is provided. Through the cooperation of participating data banks, newly determined sequences are automatically transmitted for data bank entry upon acceptance for publication, thus eliminating much delay in their availability for further research.
2. "Sequence Data Analysis," providing a forum for work involving the using of sequence data: sequence comparisons, evolutionary or functional relationships among proteins, structural analysis.
3. "Data Bases: Progress and News," devoted to the medium itself, covering aspects such as data base management, new data bases for special collections, software tools for sequence analysis, program development, software portability, and special hardware.
4. "Protein Sequence Data Bank Outprints," presenting printed output of recent entries to the National Biomedical Research Foundation data bank in Washington, D.C., and to cooperating protein sequence data banks at the Max Planck Institute in Martinsried (West Germany) and at the Tokyo Science University (Japan). Subscribers to the journal will thus have, in one source, immediate access to virtually any known protein sequence reported in the current literature.

This journal will be published by Springer International, P.O.B. 503, 1970 AM Ijmuiden, the Netherlands. The cost of the journal for the US, Canada, and Mexico is $296 per volume consisting of six issues per year. Professor A. Tsugita, Science University of Tokyo, is Chairman of the international advisory board for this journal.

GLIA

Interest in research on neuroglia cells has increased greatly in the last decade, due in part to the fact that these ubiquitous cells have been shown to play an important role in normal and abnormal brain function. Since the study of neuroglia is crucial to an understanding of the functions of the nervous system, there is a need for a single, comprehensive publication that examines exclusively this rapidly expanding branch of biomedical investigation.

GLIA is an international journal devoted primarily to the study of the form and function of neuroglia cells in health and disease. Providing a forum for a rich diversity of research disciplines, including anatomy, physiology, pharmacology, pathology, biochemistry, and clinical neurology, *GLIA* will cover a broad range of experimental topics related to research on GLIA.

The journal's bimonthly appearance will assure the prompt publication of full-length original research articles, reviews, and short communications. The journal will use a large format, insuring that figures and photomicrographs will be reproduced with the greatest possible fidelity. Preference is given to articles that have broad cross-disciplinary interest and impact.

The Editors-in-Chief are Bruce R. Ransom, Department of Neurology, Yale University School of Medicine, New Haven, Connecticut, and Helmut Kettenmann, Institute of Neurobiology, University of Heidelberg, West Germany, and the editorial board consists of an international roster of scientists. The journal is published by Alan R. Liss, Inc., 41 East 11th Street, New York. The institutional subscription price is $150 and individual price is $65.

Biocatalysis

Biocatalysis is an international journal that covers the industrial exploitation, both actual and potential, of biological catalysis, and the mechanistic principles derived from these catalysts, for the interconversion of chemical species. The journal will focus particularly on the kinetics and thermodynamics of biocatalytic process, biocatalytic stability, the use of alternative biocatalytic environments, biocatalytic modification (by genetic or protein engineering), biomimetic and bio-organic systems, alternative and novel activities of biocatalysis in relation to process design, and subsequent downstream processing. The journal will publish both full-length research papers and reviews, and occasional shorter communications.

The Managing Editor is David Best, Biotechnology Center, Cranfield Institute of Technology, Cranfield, Bedford, UK. The editorial board is international in scope. The journal is published by Harwood Academic Publishers, London, UK, and New York. The corporate subscription price is $248 per volume (4 issues per volume). The university/academic library price per volume is $152 and individual subscription price per volume is $76.

Oncogene Research

Oncogene Research is a monthly journal dedicated to reports of significant research in the genetics and molecular and cellular biology of oncogenes, their products, and factors involved in the regulation of growth of normal and cancer cells. *Oncogene Research* is intended to provide a vehicle for rapid publication of reports in this growing area of biology. The journal will publish research papers, minireviews, and short communications. Decisions on submitted papers will be made as rapidly as possible, usually within 4 weeks from the date of receipt. Publication of accepted manuscripts will be within 3 months.

Some of the various topics that will be considered for publication are:

- Molecular structure of oncogene proteins
- Function of oncogene proteins
- Cellular transformation
- Expression of oncogenes during development
- Growth factors and their receptors
- Oncogenes--gene rearrangements and other mutations
- Recessive oncogenes and tumor suppressor genes
- Tumor viruses as mutagens
- Viruses associated with human tumors and cancers
- Evolution of oncogenes
- Regulation of cell proliferation.

The Editors-in-Chief are Claudio Basilico, Department of Pathology, New York University School of Medicine, New York, and Hidesaburo Hanafusa, The Rockefeller University, New York. The editorial board consists of internationally known scientists. The journal is published by Harwood Academic Publishers, London, UK, and New York. The corporate subscription price is $160 per volume (4 issues per volume). The academic price is $130 per volume and the individual subscription price is $35 per volume.

Brain Injury

Brain Injury will be launched in July 1987 and the first volume will contain two issues. From 1988 it will be a quarterly publication.

This major new international journal is designed to be the primary vehicle of communication for professionals whose main interest is in the area of brain injury. The thrust of the journal is to present vigorously refereed papers which have scientific validity yet are readable by any professional. It will be a multidisciplinary publication including subject reviews and editorials, with contributions from scientists, neurosurgeons, neurologists, psychiatrists, psychologists, and all the rehabilitation professionals.

The Editor-in-Chief of *Brain Injury* is Henry H. Stonnington, Virginia Commonwealth University, US. The European Editor is William W. McKinlay, Western General Hospital, Edinburgh, UK, and the Japanese Editor is Takashi Tsubokawa, Nihon University, Japan. The editorial board is composed of an international group of scientists. The publisher of the journal is Taylor and Francis Ltd., London, UK, and New York and Philadelphia. The subscription price for academic libraries is $55 for Volume 1, 1987 and $28 for a personal subscription.

Clinical Materials

This new international journal is dedicated to the preclinical and clinical applications of existing and novel materials. It is intended for those in clinical practice, research, and industry who are concerned with patient care. Thus the new *Clinical Materials* satisfies a demand for rapid publication and cross-fertilization of ideas in the development and clinical application of materials in surgical, medical, and dental practice. Hence it provides a common reference tool for all practicing clinicians,

bioengineers, biochemists, and material scientists. The original scientific papers, surgical case studies, authoritative reviews and commentaries presented in the journal are intended to ensure that the true clinical potential of modern materials is realized. Readers will also be kept up to date through book and data base reviews, calendars of meetings, and information on new patents.

The chief editor is Dr. Christina Doyle, Department of Materials, Queen Mary College, University of London, UK. The journal has an international advisory editorial board with members from West European countries as well as the US, Israel, Canada, and Japan.

The journal is published quarterly by Edward Arnold Ltd., 41 Bedford Square, London, UK. The cost of the journal for US and Canada is $95 per volume (institutional) and $50 per volume (individual) inclusive of air freight service to New York. Each volume contains four issues.

Microbiology and Immunology

A new section of the Federation of European Microbiological Societies' (FEMS) *Microbiology* which will deal specifically with microbiology and immunology is being prepared in response to the growing concern regarding acquired immune deficiency syndrome, and a realization of the magnitude of problems of infection. New rapid methods are urgently needed in virology, bacteriology, and parasitology to facilitate treatment and control of epidemics and outbreaks. Veterinary microbiology and immunology are also important, as some of the most serious problems of human infection are acquired directly or indirectly from the animal world. The application of molecular biology techniques to the study of infection will affect diagnosis, and offers new possibilities of treatment by improving our ability to make vaccines or other biological products. These and other topics of interest to microbiologists and immunologists will be covered by this new section which will publish original papers dealing with all aspects of immunology in infectious disease. Preference will be given to works describing the mechanisms of immunity and how these can be exploited in the diagnosis and treatment of disease.

The Editor-in-Chief of this journal is Heather M. Dick, University of Dundee, UK. The first issue will be published in August 1987. The journal is published by Elsevier Science Publishers, Amsterdam, The Netherlands and New York. The institutional rate per volume (9 issues) is $177.75 and the personal rate is $55.50.

Claire E. Zomzely-Neurath
7/22/87

FIBER-REINFORCED GLASS COMPOSITES AT HARWELL

One of the research centers at Harwell, Atomic Energy Research Establishment (AERE), Oxfordshire, OX11 ORA, UK, is the Materials Engineering Group. This is organized as a separate business center (see *ESN* 41-7:402-405 [1987]), carrying out contract work for government and industry. The Materials Engineering Center, which is under the direction of D.T. Livey, has several specializations. They are:

- Polymer-based composites (D.H. Bowen)
- Coating technology (I.M. Buckley-Golder)
- Engineering ceramics (R.W. Davidge)
- Sol-gel processing (D. Segal)
- Electrically conducting materials (B.C. Tofield).

This note briefly reviews the work on fiber-reinforced glass-ceramic composites in the Engineering Ceramics Section, headed by Roger W. Davidge. Other members of the group are Alan Briggs and David M. Dawson.

Fiber-Reinforced Glass Composites

The group at Harwell has developed a very good method of forming a fiber-reinforced glass composite. The flowing of glass at temperature enables an intimate structure to be formed, with very few pores and with good interfacial structures between fiber and matrix. However, these composites are restricted in use to temperatures below the softening temperatures of the glass (about 500°C). Higher temperature composites can be achieved using the same method of preparation, but with a glass which can be subsequently crystallized to give a fiber-reinforced glass-ceramic composite. In this report, a description is given of the method of preparation of continuous-fiber-reinforced glass composites, and on the extension of the method to continuous-fiber-reinforced glass-ceramic composites.

Work was in progress in the 1960's on C-fiber-reinforced glass composites

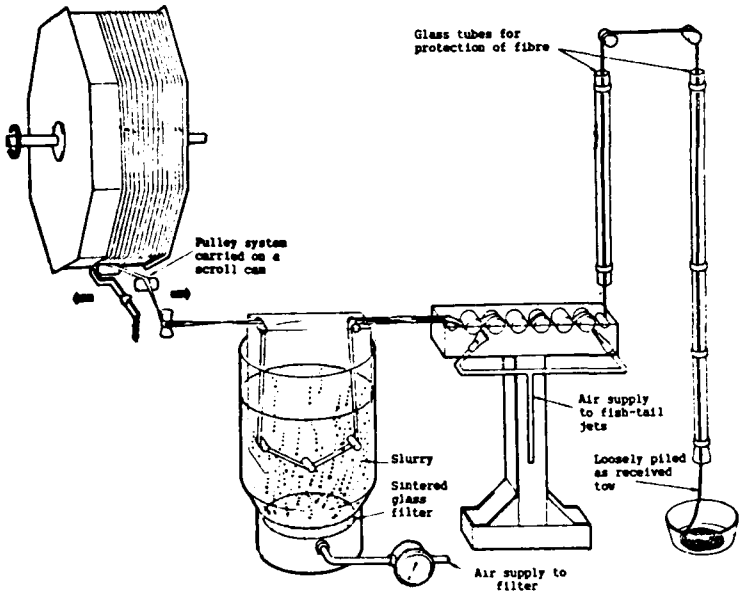

Figure 1. Fiber Impregnation and Filament Winding (Harwell).

with Rolls-Royce but was stopped in 1971. This work has been resumed in the past few years and, indeed, the Harwell composite preparation system is well known, and subsequent similar systems have been used by several laboratories in the US. The present work at Harwell is supported by the DTI/ACT program (Department of Technology and Industry, UK/Advanced Ceramic Turbine Club).

A good example of Harwell's composite work is the composite Pyrex-SiC fiber (Nicalon), which forms a stable and useful composite material to 550°C (Pyrex softens at about 570°C). The stages in the preparation are as follows (see Figure 1):

- An organic protective coating on the SiC fiber is removed by heating in a desize furnace.
- The SiC fibers are passed through a slurry of glassy particles in H_2O, so that the fibers become impregnated with the glassy particles.
- The filaments are wound around a winding drum to form flat ribbons up to 6" wide.
- The ribbons are cut into sheets called pre-preg.
- The sheets of pre-preg are stacked as required and hot pressed up to 1600°C in graphite discs.
- The final composite is built up of layers, each with aligned SiC fibers (different orientations can be chosen for the sequence of stacked layers).

The final three-dimensional composite is now a useful material (Dawson et al., 1986; Davidge, 1987). A range of die-presses is available so that components up to 12"×6" in dimension can be produced and temperature up to 1600°C used.

A very important consideration of this method of formation of ceramic-fiber glass composites is that the finished components after hot pressing have essentially the same dimensions as those of the pre-preg. A dense composite is obtained with the few pores since the glass flows around the fibers during the hot pressing.

Dawson et al. (1986) reported on a SiC-fiber-reinforced pyrex composites with 0.49 fiber volume fraction, with flexural strength 1.25 GPa, Weibull modulus 30, elastic modulus 120 GPa, and fracture work >50kJm^{-2}. Excellent properties are conserved at 500°C.

Fiber-Reinforced Glass-Ceramic Composites

The Harwell method of preparing continuous-fiber-reinforced glass composites works very well, producing composites with little porosity under well-controlled conditions. However, the maximum temperature of use of the SiC fiber-pyrex composites is about 500°C.

It is important to prepare composites capable of use at higher temperatures. The glass matrix Harwell uses should now be capable of crystallizing at high temperatures to form a ceramic (or

glass-ceramic). In this way, during preparation of the composite, the glass properties are used as before to consolidate the composite. Then the glass is crystallized at high temperatures, about 1200°C, to form a ceramic phase.

Matrix Material

A wide range of suitable glass-ceramics is available as matrices; those under study at Harwell include: (1) LiAl silicate; (spodumene/eucrytite compositions); (2) cordierite; (3) enstatite; (4) Ba ozumilite; and (5) celsian. These contain Ba, Ca or Li silicates which form glass ceramics. The composite material is consolidated in the glassy condition at about 1000°C; with subsequent firing to 1200°C, at which point the glass crystallizes to form the ceramic phase.

Continuous Ceramic Fibers

Continuous ceramic fibers need to be stable at high temperatures as well as being chemically compatible with the matrix material. It is difficult to obtain such fibers, and their properties are much more delicate. A list of 13 available continuous ceramic fiber is given in Mah et al. (1987); to that list, the continuous fiber SAFFIL (αAl_2O_3), prepared by ICI, should be added. The continuous fibers of carbon can not be used until a way is found to protect them from oxidation at higher temperatures.

A promising composite is based on coated Al_2O_3 fibers in a glass-ceramic matrix. It is necessary to coat the alumina fibers to avoid chemical reaction with the matrix since this would lead to a brittle composite. The α-Al_2O_3 fibers can be coated by SiC to avoid reaction with the silicate matrix. It is believed that composites stable to 1400°C may be prepared by this method. Present work at Harwell is on SiC-fiber in a celsian matrix.

Conclusion

The Harwell method of preparation of fiber-glass composites is very successful, using the flow properties of the glass to provide a dense composite with the minimum of porosity and good interface properties. The method is capable of being extended to higher temperature by using glass-ceramic matrices and, though several suitable matrices are readily available, the limitation lies in the restricted number of suitable ceramic fibers.

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Louis Cartz
6/5/87

GREECE'S AIR FORCE TECHNOLOGY RESEARCH CENTER

The Hellenic Air Force Technology Research Center (KETA) was established in 1977. It occupies a new building overlooking Athens and has several modern laboratories and a personnel complement of 120 people. KETA is primarily concerned with applied research and the applications of proven techniques in support of the Greek air force. KETA's effort can be divided into three parts:

- Modification of aircraft and electronic support
- Study of new concepts and innovations particularly concerning the purchase of new equipment
- Investigation of airplane accidents.

The engineering staff of KETA, which numbers about 60, hold advanced degrees principally from the US and the UK. Major M. Metochianakis, who was my host, has a master's degree and an engineer's degree in aeronautical engineering from the Naval Postgraduate school. KETA serves as the important link between Greece and the AGARD technical community. It also develops relationships between local industry and to some extent with universities. It has, for example, supplied some financial support for the new turbomachinery laboratory at the National Technical University of Athens (*ESN* 41-7:385-388[1987]).

KETA's Divisions

KETA works closely with the other components of the Greek aerospace industry although all are essentially state run. These include Hellenic Aircraft Industry (HAI), which is concerned with aircraft overhauling and engine overhaul, the Hellenic Arms Industry (EBO), which is concerned with missile weapons and gun purchases, and with the Greek Powder and

Cartridge Company (PYRAL), which makes ammunition and rockets.

Aircraft And Systems. This division is concerned with aerodynamics, structures and material, propulsion, and special projects and new concepts. The aerodynamics activity is primarily devoted to stores separation, for which the National Aerospace Laboratory (NLR) of the Netherlands supplies technical assistance. An experimental part of the program will involve cameras and rakes and an instrumented aircraft. Cameras for the program are now being purchased. A computer code for separation which originated at Elgin Air Force base is being used to predict the aerodynamics of the stores separation. Further work, concerning flutter, uses a computer code which is based on panel methods; this code was developed by Messerschmitt-Bölkow-Blohm (MBB). The flutter analysis is needed in the certification of new aircraft configurations.

The primary emphasis in the division's structures activity is on the study of fatigue. Microprocessors are being installed on aircraft to record the flight history; the flight history will be coupled with finite element analysis (using the PAFEC program) of the structure in order to gain a better understanding of lifetime predictions. The results will be used to develop specific procedures in damage tolerance.

Electronics and Communications. This division is concerned with avionics and electronic warfare. Both electronic and optical sensors are investigated in this division.

Aircraft and Ground Weapons Systems. This division is concerned with new aircraft and weapons evaluation. In the certification of new configurations and weapons there is a lot of activity at KETA. The Greek air force is concerned with, among other aircraft, the F4, F5, F104, F1, A7, Mirage 2000, and F16. As part of the work effort KETA has also designed and flown some remotely controlled drones. Aircraft engine investigations and gas turbine simulations are also in process. Some of this latter work is contracted out to academic groups.

Facilities

The KETA main computer is a Prime 450, but extensive use is also made of PC's. The laboratories have new equipment consisting of a material testing systems (MTS) testing machine, a nondestructive testing x-ray machine from the US, an electron microscope, and sophisticated Fourier analysis equipment. Some of the equipment is part of a standards laboratory that has been mandated by EEC.

Conclusion

KETA is essentially an applied research center for the air force. The people I met had a solid technical foundation. This center could become very important in furthering aerospace technology in Greece if an effort is made to involve the academic community.

Daniel J. Collins
4/28/87

HIGH-DENSITY INTERCONNECTION RESEARCH AT THE UK'S STANDARD TELECOMMUNICATIONS LABORATORY

Standard Telecommunications Laboratory (STL), located in Harlow, UK, is the primary research and development arm of STC Technology Limited. Over the years STL has been a major contributor to advances in thick film hybrid microelectronics, with activities ranging from basic research on the materials to the development of assembly and packaging techniques. Since STC acquired ICL, the computer manufacturer, there has been increased research and development activities at STL on high-density interconnection techniques. One of the major projects currently underway is looking at copper plus polyimide as a potential fine line multilayer interconnection system. Copper has the advantages of high electrical conductivity, which reduces propagation delay time between chips, and it is readily solderable. The polyimide provides an inert, low dielectric constant insulating layer between the copper layers.

The approach to high-density interconnections taken in the group headed by M.V. Coleman is to first deposit dense copper films between 5 and 10 μm thick using high deposition rate sputtering techniques. Standard photolithographic techniques are then used to produce lines and spaces of 50 μm. A solution of polyamic acid in N-methyl-2-pyrolidone is then spun onto the substrate having the photodefined copper pattern. After spinning, a two-stage cure schedule causes the polyamic acid to break down, forming an imide which then polymerizes to form a polyimide. The polyamic acid film is first partially cured by holding at 130°C for 1 hour, and then the photoresist is spun on. A via pattern is then exposed and the photoresist developed to remove the portions of photoresist and imide films where vias are required. The photoresist-coated film pattern is then further heat-treated at 130°C for 30 minutes

prior to removing the photoresist with acetone. The imide film is then fully cured at 350°C for 1 hour to form the polymer polyimide. The processing is then repeated by sputtering copper onto the polyimide layer with vias, then photodefining the desired pattern including connections to the first copper layer through the vias opened in the polyimide. The second polyimide layer is then processed the same as the first, and as many layers as required for a particular design are added in this way.

Most of the research has been done using alumina substrates, but a variety of substrate types have been tried and the only criteria seems to be a smooth surface allowing high-definition patterning and the ability to withstand the processing temperatures and chemicals used in photodefining. One of the substrates being evaluated is silicon. STL is one of the collaborators in the National Electronics Research Initiative on Silicon Hybrids, which is coordinated by the Royal Signals and Radar Establishment (RSRE) at Malvern. The objective of STL's contribution to the initiative is to investigate the properties of silicon for substrates with interconnect scaling comparable to that of wafers, and the copper polyimide system is the first approach they are evaluating. The type of sputtering and alignment equipment and the level of cleanliness required is typical of that used for 5-μm silicon.

The STL people believe that the copper-polyimide technology provides a complement to existing hybrid technology, and are investigating some interesting possibilities with a ceramic multilayer substrate to produce customized packaging at a level of sophistication not achievable by conventional hybrid multilayer systems. By careful partitioning of the circuit functions, the high-speed requirements for addressing VLSI devices can be achieved by the copper-polyimide route, and the less demanding circuit interconnections are built into the cofired multilayer ceramic substrates.

Robert W. Vest
7/21/87

ENGINEERING CERAMICS MEETING, LONDON, UK

A 2-day symposium on engineering ceramics will be held in London, UK, 23-24 November 1987. This short notice was unavoidable, but since there is no deadline for registration, there is still time.

The meeting is being organized by IBC Technical Services Ltd., Canada Road, Byfleet, Surrey, UK. The invited speakers are:

- Dr. G.J. Wurm, "Ceramic Programme Cooperation within the European Communities,"
- Professor P. Boch, "Prestandardization Studies to Stimulate the Use of Engineering Ceramics,"
- Dr. F.J.Cambier, "An Overview of the Movements in the Engineering Ceramics Area 1985-87,"
- Dr. I. Kvernes, "Protection Materials-Coatings for Thermal Barriers and Wear Resistance,"
- Dr. B.G. Newland, "The Production of High-Grade Technical Ceramics,"
- Dr. K. Goebbels, "Non Destructive Testing of Ceramics,"
- Dr. H. Knoch, "Non-Oxide Technical Ceramics,"
- Dr. B. Cales, "Ceramic Matrix Composites,"
- Dr. J. Huber, "Ceramics in Internal Combustion Engines,"
- Professor R.C. Bradt, "Ceramic Engine Programs in the USA,"
- Dr. D.A. Parker, "Developments in the UK Engineering Ceramics Programmes,"
- Dr. H. Suzuki, "The Present Attitude towards High Technology Ceramics in Japan."

Further information can be obtained from Dr. Louis Cartz, Office of Naval Research Branch Office London, P.O. Box 39, FPO New York 09510. Telephone (autovon) 235-4478, (commercial) 44-1-409-4478.

Louis Cartz
8/4/87

THE UK'S COMPUTATIONAL MECHANICS INSTITUTE--SOFTWARE, TEACHING, AND PUBLICATION

The Computational Mechanics Institute (CMI, Southampton, UK) is directed by Dr. C. Brebbia, who has his doctorate from the University of Southampton and has been a professor of civil engineering at the University of California at Irvine. CMI is an interesting institute that combines elements of a private software and research company, a teaching institute, and a scientific publishing company. There is a small staff of about 15 people. Following are comments on CMI's three activities.

Software

The software and research efforts are directed at the development and sale

of a computer code called the Boundary Element Analysis System (BEASY). The boundary element method (BEM) is typically directed at problems of potential analysis and of stress analysis--that is, elliptical problems in which a well-posed problem is obtained by specification of the conditions on the boundary. Contrary to the finite element method only boundary elements are specified in the solution of a problem. The method is a combination of the classical boundary integral equations methods and interpolation concepts originating with finite elements. Some 70 companies and universities are presently using this code in the US, and the code is also extensively used in Europe and Japan. Brebbia's research interests and publications are concerned with the extension and application of the boundary element method. A recent publication (Brebbia and Nardini, 1986) has been directed at the extension of the BEM to parabolic and hyperbolic time-dependent problems. Other work has considered the analysis and design of automobile components and the solution of heat transfer problems by the BEM.

Teaching

The educational function has been, until recently, principally in the area of short courses and conferences. The short courses cover a wide variety of subjects such as fracture mechanics and shell analysis. Two new programs have been recently introduced that can materially extend the educational and research base of CMI. In the first program, the Council for National Academic Awards (CNAA) has approved the Institute for the award of a Doctor of Philosophy degree. There are now six doctoral students from Japan, Italy, China, Morrocco, and Brazil studying at CMI's comfortable facilities in the New Forest. The doctoral research is directed at advanced analysis techniques and computer aided engineering and, as such, complements CMI's software activity. In the second program, a new 13-week course on computer aided engineering (CAE) has been instituted as well as a program with 27 academic credits in CAE that could lead to a master's degree, which the institute can also award. A recent application of the computer aided design effort that has direct application to the the US Navy is a computer aided design of cathodic protection systems. Brebbia indicated that he had discussed this corrosion protection analysis method with people from several navy facilities.

Publications

CMI publishes 11 quarterly scientific journals. Some of the titles of these publications are *Applied Ocean Research, Probabilistic Engineering Mechanics, Engineering Analysis,* and *Microsoftware for Engineers.* Several of the journals are edited by Brebbia and carry articles which feature analysis and solution of problems based on the BEM.

Reference

Brebbia, C.A., and D. Nardini, "Solution of Parabolic and Hyperbolic Time Dependent Problems Using Boundary Elements," *Computers and Mathematics with Applications,* 12B 5/6 (1986), 1061-1072.

Daniel J. Collins
7/17/87

RESEARCH IN AIR-SEA INTERFACE AT IMST, LUMINY, FRANCE

France's Institut de Mécanique Statistique de la Turbulence (IMST) of the Université d'aix-Marseille has a separate facility located at the Luminy campus of the university devoted primarily to the study of the air-sea interface. I visited this installation in May 1987. The director of the lab, A. Ramamonjiarisoa, my host, described both the facilities and the activities of the staff. The staff is composed of 19 professional people plus support personnel who operate and maintain the two major air-sea interaction research tools located at this installation. These are two very similar design water channels, each having the capability of wave and current production in the water channel, while at the same time a variable air stream is located just above the water surface so that wind-generated waves may also be produced. The larger tank is 61 m long (200 ft) with a test section 40 m long, 3.2 m high, and 1.5 m wide. The smaller tank is only 8 m long with an appropriately scaled-down test section. Both test sections are well instrumented for the measurement of temperature, humidity, and motion profiles.

Air-Sea Interface

As might be expected, just about all the research done at the Luminy location revolves around data taken in these tanks. Atmospheric turbulence over various sea-surface configurations has been a very active topic, with some staff members participating in the Humidity Exchange Over Sea (HEXOS) program. The generation and nonlinear evolution of both gravity and gravity-capillary waves

is being studied, as is the energy transfer from the atmosphere to the sea surface, and the mechanism of gas exchange across the air-sea interface. An attempt is being made, using a Cray supercomputer located in Paris, to model some of the phenomena observed in the tanks. Experimental results indicate a strong dependence on the interaction between a drift current and waves, which increases in complexity when breaking (with the associated bubble entrainment) occurs. A laser measuring system is being used to record bubble size distribution and population with depth, and numerical models are being developed to explain the processes at work.

Radar Backscatter

The effect of different sea-surface configurations on scattered electromagnetic signals is also being studied. A radar scatterometer simulator has been mounted above the larger test flume so that basic relationships between sea-surface configuration and scattered EM signal can be ascertained. Different wind speeds, plus independent conditions produced by currents and separately generated waves, along with any synergistic effects, can be examined. These data, along with any relationships that result, should be invaluable when it comes time to interpret scatterometer data from the ERS-1 satellite. At the same time, though, a much better understanding of the basic physical processes involved in the operation of the scatterometer should be acquired. Attempts are also being made to identify the portion of the waves actually doing the backscattering, and in the process, develop some sort of a consistent scattering theory.

Wave Breaking

Another active project concerns the actual wave breaking process. The small tank is being used in conjunction with video recording for data acquisition. Individual video frames are digitized to delineate the air-water interface as breaking proceeds, and these data are then computer analyzed. So far, over 4000 frames have been digitized, each composed of 250,000 pixels (500×500). Present objectives are to specify and quantify both wave parameters just before, during, and after breaking and to specify and quantify bubble entrainment by spilling and plunging breakers. Experiments so far have shown that waves will break not only due to high wind speeds, but also from instabilities produced as a result of wave groups. At this point, it appears that the slope of the front crest is the most critical parameter in the determination of breaking. However, by using new statistical analysis techniques available with automatically digitized video frames, it should be possible in the near future to determine the statistical significance of up to 40 different wave parameters.

Summary

The Luminy branch of IMST is a relatively small laboratory, but it is doing some extremely important work. In large measure this is a result of the fact that the lab has rather unique test facilities. Nevertheless, these two tanks are well used and the results speak for themselves. I got the distinct impression that a major reason for this success lies with the director, Dr. A. Ramanonjiarisoa, who has managed to put together a productive staff and keep them producing. In many respects the work being done here is unique, and as is usually the case, other laboratories will attempt to duplicate this effort. However, they will have to aim high to match what I saw at Luminy.

Jerome Williams
7/14/87

OCEANOGRAPHY AT A SMALL LABORATORY IN TOULON, FRANCE

Associated with both the Université de Toulon and the Centre National de la Recherche Scientifique (CNRS), the Laboratoire de Sondages Electromagnetiques de l'Environnement Terrestre (LSEET) is engaged in developing and understanding methodologies employing microwave technology for use in environmental measurements. These activities include the development of techniques for sounding both ionospheric and lower and middle atmospheric properties, and looking at turbulence and circulation in the entire atmospheric volume. A VHF radar is now being used for sounding the first 10 km of the lower atmosphere, while a cooperative ionospheric sounding program with both the US (the Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland) and Canada is being pursued in the Arctic. In addition, there is some interest in using microwave techniques to study the ocean surface. I spoke with P. Forget, who described some of the ocean work that has been done.

Radar Oceanography

LSEET has been involved with the use of HF radar for remotely sensing sea state and surface currents since 1976.

Unfortunately, several severe problems remain. The relationship between the radar return signal and sea state is poorly understood, and it is difficult to delineate what is actually being measured when attempts are made to compare radar data with "sea truth." The radar signal represents some sort of a spatial average (over a square 2 km on a side in this case), taken at a specific instant in time, while buoy data represent some sort of a time average, taken at a specific spot in space. Forget also indicated that their data imply a strong effect of wind and waves on measured current, an effect which remains unquantified at this time. Nevertheless, LSEET has made some progress. They believe the radar measurements of current are very closely related to the sum of residual circulation and Stokes drift, and it appears that the system works best in shallower areas. One aspect of LSEET's system that seems to be somewhat better than most other HF systems is the antenna. They use a large, directional array (250 m-wide) which can be steered by phase changes in specific antenna elements. In this manner directional changes of as much as 50 degrees can be accomplished. Forget's group also claims reproducibility of ±5 cm/s in current measurements.

Other Current-Associated Efforts

In what might be considered to be a natural follow-on to the HF work described above, more recent efforts have been directed toward producing a similar VHF system. From preliminary tests, it appears that the VHF rig can be used in much the same manner as the HF, and it does as well, with the distinct advantage of smaller size.

Associated with this hardware development exercise, a small group has been formed to initiate some numerical models that would be applicable to the study as a whole. This group is attempting to model the effect of wind on surface currents, as well as subsurface circulation. In addition, they are looking at possible interactions between Ekman and Stokes transports.

Other Remote-Sensing Efforts

A small amount of work directed toward a better understanding of synthetic aperture radar (SAR) signals is being supported by LSEET in conjunction with the ERS-1 satellite program. Forget is looking at radar returns from linear systems (long, small-amplitude swell); nonlinear, nondestructive systems (period and wavelength are conserved); and nonlinear, destructive systems, which are best imaged with low-altitude radars. This work involves the consideration of appropriate transfer functions between radar return and the wave field. So far he has found--at least with SEASAT data--that he is able to develop transfer functions that work as long as the sea state is such that it may be considered a linear system.

Some work has also been done in the analysis of data acquired from an aircraft-mounted SAR in connection with the Gibraltar Experiment. Here there was some success in looking at the internal wave field.

Summary

LSEET is a small laboratory, employing less than a dozen professionals. Although some attention is being given to measurement problems associated with the ocean surface, the major effort seems to be in other areas. The basic analysis work, which attempts to develop theoretical bases for relationships between radar and sea-surface parameters, is of great interest to many people and, consequently, is being done--although somewhat differently--at other laboratories. My impression of LSEET was that the work in the oceanic area was of high quality, but not unique.

Jerome Williams
7/13/87

BRITISH INSTITUTE OF OCEANOGRAPHIC SCIENCES (IOS) REORGANIZED AND RENAMED

On 1 April 1987 the Institute of Oceanographic Sciences (IOS) laboratory at Wormley became the Deacon Oceanographic Laboratory (DOC) while the IOS laboratory facility located at Bidston was renamed the Proudman Oceanographic Laboratory (POL). The major research thrust at each of the laboratories remains the same, but the responsibility structure has been changed. Contrary to the previous organization where the Bidston Laboratory reported to the Wormley facility, now both laboratories have equal status and report directly to the Director of Marine Sciences at the National Environmental Research Council (NERC).

Jerome Williams
7/22/87

BRITISH AEROSPACE AND THE SPACE TELESCOPE

British Aerospace is the prime contractor for probably the most important equipment components of the NASA-ESA Hubble Space Telescope project. Its Space and Communication Division, under contract with ESA, has already supplied the solar arrays which provide the power for the telescope, and the photon detector assembly (PDA) which is the central element in the faint-object camera (FOC). A new, £1.2 million ($1.9 million) contract, awarded in March, will cover the construction of additional cameras for upgrading some of the PDA's; it will update the manufacturing technologies used on the image intensifiers; and it will further increase the capabilities of the PDA's video processor unit (VPU).

The cylindrically shaped Space Telescope, 14.3 m long and 4.7 m in diameter, will operate at an altitude of 500 km. With its supersensitive optical equipment, it will allow us to see objects at a distance of about 14 billion light years away, thus expanding the part of the universe visible to man by a factor of 350...to an epoch probably rather near to the Big Bang. Launch is expected by the European Community to take place in late 1988--provided the US Space Shuttle program resumes as planned.

More information on the British Aerospace contribution can be obtained from Mr. J. Humby, PR Manager, British Aerospace Space and Communications Division, Argyle Way, Stevenage, SG1 2AS. Phone: (44) (0438) 313-456.

Paul Roman
7/22/87

FIBER-OPTIC TELEMETRY AT THE ELECTRIC COMPANY OF PORTUGAL

Interesting, albeit low-key research and development may be found at unlikely places. A point in case is the Central Research Laboratory of the Electricidade de Portugal at Sacavém (a northern suburb of Lisbon). The director (and founder) is Professor R. Leuschner Fernandes. My particular focus of interest was the so-called Department of Applied Electronics, headed by the able Dr. A. Adelino Bray. This department employs six scientists (mainly electrical engineers) and 10 technicians. One of its major responsibilities is the development of very specific, but simple, reliable sensor-data transmission systems that are not available on the market. They have successfully attacked the problem of accepting signals from conventional sensors in an environment of extremely high (and unpredictable) electromagnetic background noise, and transmitting the information, through fiber-optics, to a monitoring point a few hundred meters away, but also in an environment of electromagnetic noise. The quantities to be monitored are voltage, current, power, current leakage, and, at a later time in the future, temperature and pressure. Multimode fibers are used, with a LED source (analog direct modulation), and a p-i-n FET receiver is employed. The analog data are digitized (in many cases a "present or absent" signal is sufficient). But the real problem is the design of the electronics that can work uninfluenced by the very-broad-band, high-intensity, unexpectedly changing electromagnetic radiation background noise.

One of the recent achievements of the researchers was the development and testing of a six-channel transmission system on a single fiber (using time division multiplexing). The bandwidths vary between zero and a few 10-thousands kHz.

Despite its simplicity, I learned a great deal from observing this research activity.

Paul Roman
7/22/87

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two DOD employees for registration-free participation in the conferences ONRL supports. Readers who are DOD employees and are interested in a free registration to one of these conferences should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Portugal and Spain Conference on Social Psychology to be held at Tomar, Portugal, 6-7 November 1987.

Conference on Hypersonics to be held in Paris, France, 7-11 December 1987.

Controversies in the Social Explanation of Psychological Behavior to be held in Paris, France, 14-16 January 1988.

ONRL REPORTS

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONR, London.

Multidiscipline

The British Technology Group, by J.F. Blackburn. (7-022-R) The British Technology Group, when it was established in 1981, incorporated the National Research Development Corporation and the National Enterprise Board. Its primary purpose is to encourage and facilitate transfer of new ideas and technology from university and government laboratories to industry. This report reviews the Group's current activities.

Istituto Di Ricera Sulle Onde Elettromagnet, An Italian Research Institute, by Daniel J. Collins. (7-021-R) The activities of this laboratory are reviewed. Of particular interest is the work in micro-optics and optical sensors, integrated optics, remote sensing, and signal processing.

Behavioral Sciences

An Assessment of the NATO Advanced Research Workshop on Environmental Psychology and Its Participants, by William D. Crano. (7-018-C) This report on the workshop on European social and environmental psychology, held in Lisbon in September 1986, provides a brief summary of the author's reactions to the meeting, along with some observations on the young Portuguese, Spanish, and Italian social researchers represented there.

Biological Sciences

Biotechnology Conference: Protein Engineering '87, University of Oxford, UK, by Claire E. Zomzeley-Neurath. (7-019-C) Presentations at this major international conference held at the University of Oxford, UK, in April 1987 are reviewed. The topics include theoretical aspects of protein structure, protein structure and dynamics, protein engineering methods, protein engineering stability, protein engineering binding and catalysis, and protein engineering medical and industrial applications.

Review of Cytoskeleton Research in Cell Differentiation and Development, by Claire E. Zomzeley-Neurath. (7-024-C) Papers given at this conference, held in April 1987 in Granada, Spain, are reviewed. The papers focused on the analysis of the assembly dynamics of microtubules, intermediate filaments, and action filaments to provide the structural basis of the role played by the cytoskeleton in differentiating a variety of cell systems, early embryogenesis, and the biological and genetic aspects of cytoplasmic organization.

Material Sciences

Ceramic-Ceramic Composites Meeting in Belgium, by Louis Cartz. (7-020-R) The problems of obtaining homogeneous dispersions of multicomponent systems were frequently discussed at this conference. The use of acoustic emission was shown to be a useful NDT analytical tool to detect the presence of microcracks in different phases. The composite systems considered at the meeting included: zirconia-toughened alumina (ZTA), SiC fiber-reinforced pyrex, SiC fiber-reinforced SiO_2 glass matrix, mullite-zirconia-Al_2O_3-SiC, C-fiber-reinforced reaction-bonded SiC, ionic conducting NASICON-glass insulator composites, and γAlON-Al_2O_3 composites. The zirconium oxycarbide system, ZrO_2-ZrC_xO_y and ZrC-ZrC_xO_y composites are interesting, novel systems.

Mechanics

International Conference on the Aerodynamics at Low Reynolds Numbers Between 10^4 and 10^6, by Thomas J. Mueller. (7-023-C) Presentation made at this conference are reviewed. Topics include airfoil design methods and verification, airfoil calculation methods, low Reynolds number research at NASA Langley, unsteady aerodynamic characteristics, wind turbine applications, separation bubbles, experimental facilities and testing and remotely piloted vehicles.

OVERSEAS TRAVELERS

Notes on trip reports to locations in Europe and the Middle East which have been received by ONRL are given below. For details, contact the traveler directly.

Acoustics/Oceanography

Traveler: Mr. G. Brooke Farquhar, Naval Ocean Research and Development Activity, Liaison Office, 800 North Quincy Street, Arlington, Virginia 22217-5000.

Farquhar, with Dr. Richard H. Love and Mr. Coleman Levenson of the Ocean Acoustics Division of NORDA (NSTL, Mississippi), visited various marine research institutions in Iceland, Norway, Denmark, and the UK. The visits were in connection with research projects at NORDA on low-frequency volume reverberation.

Institutions they visited were the:

- Marine Research Institute (Hafrannsoknastofnun), Reykjavik, Iceland
- Marine Research Institute, Directorate of Fisheries (Fiskeridirektoratets Havforskningsinstitutt), Bergen, Norway
- International council for the Exploration of the Sea (ICES), Copenhagen, Denmark
- Danish Institute for Fisheries and Marine Research (Danmarks Fiskeri-og Havundersogelser), Charlottenlund Slot, Denmark
- Greenland Fisheries and Environmental Research Institute, Charlottenlund Slot, Denmark
- Fisheries Laboratory, Lowestoft, England
- Scott Polar Institute, Cambridge, England
- Marine Laboratory of the Department of Agriculture and Fisheries, Aberdeen, Scotland.

Farquhar's report gives a summary of and comments on the activities, facilities, and organization of these institutions. In his company's statement, he says, "...the directors and working level scientists with whom we met were most cooperative and helpful. We were able to, in our discussions with the scientists, tap their many years of experience and considerable knowledge. We also gathered together a large quantity of reports and hard data not routinely available in this [the US] country."

Energetic Materials/Chemistry

Traveler: Dr. Kurt F. Mueller, Head of Energetic Materials Division, and Mr. M. Stosz, EAD Program, Naval Surface Weapons Center, Code R10, Dahlgren, Virginia 22448-5000.

Dr. Mueller and Mr. Stosz visited several different West German government and industry establishments which are involved in the testing, qualification, development, research, and production of explosives and related technology. Their 10-page report provides relevant details on each of the activities, describing the work and special facilities, and identifying the individuals with whom they talked.

Physics

Traveler: Dr. Kenneth C. Hass, Division of Applied Sciences, Harvard University, Pierie Hall, Cambridge, Massachusetts 02138.

Dr. Hass attended the XVI International School on the Physics of Semiconducting Compounds, held at Jaszowic, Poland, in April 1987, where he presented an invited talk, "Band Structures of Semimagnetic Compounds."

The meeting was attended by approximately 200 Poles and 50 foreign guests including 10 invited speakers. Topics included high-temperature superconductors, growth of GaAs, semimagnetic semiconductors, IV-VI doping superlattices, recombination in III-V superlattices, novel tunneling spectroscopy for shallow impurities, and growth of HgCdTe in space.

Hass' report includes information of significance in each of these topics. He also included a list of key contacts in both East and West Europe.

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Information on each of the reports listed below was furnished by the activity identified by the abbreviations for that office. Requests for copies of or information about the document should be addressed to the appropriate office:

USARDSG--US Army Research Development and Standardization Group, Box 15/65, FPO New York, 09510-1500
EOARD--European Office of Aerospace Research and Development, Box 14, FPO, New York 09510

Multidiscipline

Scientific Highlights, (Spring 1987), a quarterly report by the US Army Research, Development and Standardization Group (UK). (31 pp) [Request by title from USARDSG.]

This report presents summaries of selected European research and technology transfer projects concerned with material sciences, chemistry, computer science, physics, mechanics, and acoustics. The report also includes information on workshops and conferences supported by the Group.

Chemistry

Super Critical Fluid Chromatography Research, by MAJ Scott Shackelford, EOARD. (13 pp) [EOARD-LR-87-36.]

Professor Tyge Griebrokk, University of Oslo, Norway, is researching a new high-resolution separation technique called supercritical fluid chromatography (SCFC) which provides an important bridge between conventional HPLC and GLPC. His research seeks to define SCFC's scope of capability and to determine its potentially unique applications. SCFC uses a liquid mobile phase, which is a gas liquified beyond its critical point (e.g., CO_2). SCFC can be used on organic compounds with moderate polarity and has the inherent advantage of using a mobile phase at low temperature (30°C) which provides fast transport with minimum diffusion. Pressure rather than temperature is the parametric variable used for a given liquid carrier "gas."

Fundamental Heterogenous Surface Catalysis Mechanisms, by MAJ Scott Shackelford, EOARD. (8 pp) [EOARD-LR-87-35.]

Dr. Alfons Baiker, Eidgenoessiche Technische Hochschule (ETH), Zurich, Switzerland conducts studies with amorphous metal alloy surfaces and V_2O_5 thin-film catalysis. The systematic correlation of surface microstructure/morphology to chemical reaction mechanisms is their objective. The amorphous metal alloy samples are prepared by melt spinning and are quenched at a 10^6 degree per second rate. Dr. Baiker's group was the first to apply scanning tunneling microscopy to these samples. Carrier surface microstructure with immobilized V_2O_5 film is being studied to gain the parametric data needed for producing support surface features which provide optimum V-O bond availability in oxidative catalysis reactions.

High-Resolution Spectroscopy Advance, by MAJ Scott Shackelford, EOARD. (7 pp) [EOARD-LR-87-34.]

Professor Martin Quark, Eidgenoessiche Technische Hochschule (ETH), Zurich, Switzerland, has developed a high-resolution FTIR technique which uses a supersonic free jet interface. This supersonic free jet assembly produces exceptionally well-resolved rotational and vibrational energy spectra for small molecules and permits more detailed study of electronic reaction mechanisms. Current capability in this field is limited to gaseous molecules no larger than five "heavy" atoms (at.wt. H). Within the next 6 months, Professor Quark expects this technique will produce the first high-resolution spectra on $HC(CF_3)_3$, a model compound with 14 heavy atoms. Such vibrational and rotational spectral data will provide valuable experimental data for comparison to theoretical computations which model potential energy surfaces and chemical reaction dynamics behavior.

Molecular Dynamics and Spectroscopy at HTE University of Nottingham, by LTC LaRell Smith, EOARD. (10 pp) [EOARD-LR-87-37.]

Dr. Peter Sarre and his research group at Nottingham have an exceptional capability for studying intermediate areas in chemical bonding between the regions of fully bonded and completely separated atoms. This very important area of the threshold of bonding (and dissociation) has been extremely difficult to study because of

the experimental difficulty. Their technique, which involves laser photodissociation of very well characterized ions, can give spectroscopic resolution of better than 50 MHz. The most notable features of the experiment are the extent to which the initial state is defined in energy, angular momentum, parity and lifetime, and the direct measurement of the translational energy and angular distribution of the photoproduct. Their work thus far has involved primarily investigations of CH^+, SiH^+, and SiH_2^+.

Electronics

AI Research at the Turing Institute, by MAJ Mel Townsend, EOARD. (10 pp) [EOARD-LR-87-50.]

The Turing Institute concentrates in the inductive (vs. deductive) method of AI technology with strong emphasis in AI applied to machine vision and robotics. In conjunction with Strathclyde, the institute has bid to set up a National Robotics Center under the UK Alvey program. This report contains the institutes' brochure and descriptions and application to the AI library.

Electron-Phonon Interaction in GaAs/AlGaAs Structures, a report under contract DAJA-45-C-0046 by M.N. Wybourne, GEC Research plc, UK. (2 pp) [GEC Report No. 17,087C. Request information from USARDSG.]

The major advance in this study was the elucidation of the phonon scattering mechanism at surfaces, which will be of considerable significance when phonon scattering data from semiconductor interfaces or boundaries are analyzed. Several heater films were studied, and it was found that the detected signal amplitude, the pulse stretching factor, and the ratio of the detected longitudinal and transverse signal amptitudes were dependent on the thickness and the type of material used to fabricate a particular heater film.

Life Sciences

Biochemical Enhancement of Performance, by MAJ Jim McDougal, EOARD. (4 pp) [EOARD-LR-87-45.]

RAF Group Captain Tony Nicholson heads a very active group which is investigating several aspects of biochemical enhancement of performance, and effects of prescription drugs on performance. He uses a sleep laboratory, electroencephalograms, a battery of performance tests, and field studies, including in-flight monitoring, to study various benzodiazapines, antihistamines, and antihypertensives. This group is also interested in the effects of drugs on sleep at high altitude. They have developed preliminary computer programs to analyze electroencephalograms, predict circadian rhythms, and determine optimum shift schedules.

Electric and Magnetic Activity of the Central Nervous System, by MAJ Jim McDougal, EOARD. (9 pp) [EOARD-LR-87-51.]

During the week of 25 May 1987 the AGARD Aerospace Medical Panel held a symposium on "Electric and Magnetic Activity of the Central Nervous System: Research and Clinical Applications in Aerospace Medicine" in Trondheim, Norway. This symposium was attended by a total of 94 panel members, presenters, and observers from various NATO countries and an observer from one non-NATO country (Israel). Thirty-seven papers were presented.

Materials

Fragmentation and Cracking of Solids, by LTC Jim Hansen, EOARD. (11 pp) [EOARD-LR-87-26.]

Theoretical methods from statistical physics have been applied to cracking and fragmentation of solids. Personnel at SOREQ Nuclear Research Center, Israel, use percolation theory, transport theory, and maximum entropy to model damage in ceramics, metals, and rock.

Ceramics Research at the Technion-Israel Institute of Technology, by LTC Jim Hansen, EOARD. (32 pp) [EOARD-LR-87-32.]

Professor Brandon is hot pressing ceramic-ceramic composites. He makes laminates of either alumina or cordierite fibers reinforced with Nicolon fibers and uses ceramic whiskers to reinforce alumina. Professor Gal-Or coats and impregnates carbon-carbon composites with thin ceramic coatings (SiC or ZrO_2) using an electrophoretic deposition process. The goal of this research is to produce oxidation-resistant carbon-carbon.

The Growth of Corner Cracks Under Conjoint Action of High and Low Cycle Fatigue, a report under contract F49620-85-C-0116DEF by B.E. Powell, I. Henderson, and R.F. Hall of Portsmouth Polytechnic, Portsmouth, UK. (71 pp) [EOARD report AFWAL-TR-87.]

Fatigue crack propagation rates have been measured for Ti-6Al-4V and Ti-5331S aeroengine disc materials using compact tension and corner-notched tensile test-pieces. The loadings used simulate both the start-stop operations of aeroengines, which lead to low-cycle fatigue, and the in-flight vibrations, which may cause high-cycle fatigue. It is suggested that the different fatigue crack growth behaviour of Ti-5331S, relative to that of Ti-6Al-4V, arises largely from the greater proportion of crack closure and short crack growth occurring in this alloy.

Thermodynamic and Transport Properties in Molten Salts, Sol Gels, and Fluoride Glasses, by LTC LaRell Smith, EOARD. (33 pp) [EOARD-LR-87-41.]

The research group of Professor A.M. Elias at the University of Lisbon is doing excellent research on fundamental transport properties. In addition to recent work on complex formation and its effect on transport properties in chloride molten salts, they have done work on a new method for optical fiber production using sol-gel processing. Hydrolytic polycondensation of tetrametoxysilane using a low concentration of alpha-picoline, 1.56×10^{-3} percent in water, gives SiO2 gel which was dried at 22°C to a transparent amorphous material. The main advantage of this process is economy, but the research group is also investigating the possibility of producing glasses with new compositions not easily attained by conventional techniques.

Mechanics

Radial Mixing in Turbomachines, an interim report under contract AFOSR-85-0167 by J. De Ruyck, Ch. Hirsh, and E. Toorman, Vrije Universiteit, Brussels, Belgium. [No report number given. Request information from EOARD.]

The main tools for the prediction of convective radial mixing are developed. The secondary flows needed for the convective mixing are found from pitch-averaged vorticity equations combined with integral methods for the computation of 3D end-wall boundary layers, 3D profile boundary layers, and 3D asymmetric wakes. This integral approach requires less approximations than previous radial mixing theories and only three empirical constants are required. The convective mixing coefficient of Adkins and Smith is found from the resulting secondary flow velocities. The method is applied to some standard test cases, where secondary flow patterns are compared with available test data.

Meteorology

Improved Snow and Cloud Monitoring in the Marginal Cryosphere, an interim report under contract AFOSR-86-0195 by K. McGuffie and A. Henderson-Sellers, University of Liverpool, UK. (190 pp) [No report number given. Request information from EOARD.]

The two nephanalysis algorithms of the US Air Force, 3D Nephanalysis and RT Nephanalysis, have been examined intensively with particular, but not exclusive, attention being paid to the area of the marginal cryosphere in the northern hemisphere. Primary aims were (1) consideration of the impact upon the nephanalysis output of the inclusion of conventional, mostly surface, reports, and (2) consideration of the effect upon satellite-based retrievals of spatial sampling prior to analysis. We find that sampling of satellite data results in a much poorer correlation with surface observations and, we assert, to a poorer overall result. A number of geographically and climatologically diverse regions have been studied including (a) the tropical Amazon, (b) the Canadian arctic, (c) NW Europe, (d) the east central Pacific, Atlantic, and Indian Oceans, and (e) tropical Africa. The most important conclusion is that inclusion of conventional observations considerably improves nephanalysis output in many (probably all) locations. This is especially true in the cryospheric region where incorrect snow-cover information leads to visible radiances being used in the automated retrieval and hence, sometimes, rather poor analyses which are at variance with the conventional reports, also included in RT nephanalysis. We also find that surface observers do a better job in near-coastal locations and in multilayer cloud situations. Moreover the well-known surface observer bias towards overestimation of near-horizon cloud amount can not be shown to be a universal result and must, therefore, be thoroughly tested. On the other hand all-sky cameras do provide useful data against which conventional observations are found to compare well and with which it should be possible to test satellite-based cloud retrievals. As a subsidiary result of this project, data are now available from the Arctic, NW Europe, tropical Africa, and the central Pacific for direct intercomparison with ISCCP results as soon as they become available.

Physics

Plasma Physics Research at the University of Stuttgart, by Dr. Stacey Lazdinis, EOARD. (3 pp) [EOARD-LR-87-21.]

The Institut für Plasma Forschung at the University of Stuttgart is reorienting its research efforts. It is decreasing its work load in plasma fusion and increasing the emphasis on solving more pay-off directed problems in plasma physics.

TECHNOLOGY ROUNDUP--ITALY

The items below were received from the American Embassy in Rome. For further information, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, Rome, APO New York 09794-0007.

National Center for Materials Research and Development Being Developed. The Puglia region, the Italian National Research Council (CNR), the Italian National Agency for Nuclear and Renewable Energies (ENEA), the Second University of Rome, the University of Lecce, and the financing society Finpuglia formed a consortium to establish a National Center for Materials Research and Development in Brindisi. The center will start operating in the fall under the direction of Professor Paolo Cavallieri, vice president of the CNR national committee for physics. It will focus on the development and the identification of new areas for the applications of metallic materials, semiconductors, and ceramic materials.

Industry-University Linkup--First of a Kind. The Italian pharmaceutical firm Farmindustria has signed an agreement with the University of Turin to conduct basic research in pharmaceutical products. The agreement, the first of its kind in Italy between a private industry and a university, will likely be extended to include CNR.

Participation in Tri-Nation Space Studies. The Italian National Research Council (CNR) Space Division, in cooperation with the French National Center for Space Studies (CNES), and the Spanish National Institute of Aerospace Technology (INTA), began launching in June five stratospheric balloons from the Sicilian base of Trapani Milo. The balloons will fly at an altitude of 40 kilometers and will be recovered in Spain. They will carry experiments to:

- Measure the thermal balance of balloons in flight
- Study the infrared polarization of the cosmic background
- Study x-ray sources from galaxies.

SCIENCE NEWSBRIEFS FOR OCTOBER

The following issue of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during October. *Science Newsbrief* provides concise accounts of scientific research developments, meeting announcements, and science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Number	
5-8	Fluid Mechanics Meetings in Europe and the Middle East 1987-89 by Eugene F. Brown.
5-9	Acoustic Scavenging of the Open Air by Louis Cartz.

OCTOBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during June. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the *Bulletins*, by number, from ONR, London.

Number	
25-87	Anti-Ship Missile Towed Decoy
26-87	Second Quarterly Index 1987
27-87	SIREN Offboard Countermeasures System

OCTOBER MAS BULLETINS (CONT'D)

Number	
28-87	French Spaceplane-HERMES Update
29-87	RINA Warship '87
30-87	Hydrographic Survey Training Simulator
31-87	A Passive Preprogramed Memory Using Thick-Film Technology
32-87	The PALLAS Man-Tended Free Flyer
33-87	Siemens Ready to Supply High-Power Semiconductor Laser Arrays
34-87	New Laser Warning System
35-87	A Pioneering Artificial Intelligence Computer
36-87	Space Highlights 1987 Paris Air Show
37-87	SPOT-1 Satellite Performance Evaluation
38-87	European Space Agency--Current Programs
39-87	Marconi Space Systems Activities: Marconi Research Centre
40-87	Conference Alert--Aerotech 87--Aerospace Technology Center and Exhibition Center, Birmingham, UK, October 27-30, 1987

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